PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIX. MARCH TO DECEMBER, 1880. No. 107.

TABLE OF CONTENTS.

EXTRACT FROM THE BY-LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE.

Vol. XIX.

MARCH 1880 TO DEC. 1881.

PHILADELPHIA:
PRINTED FOR THE SOCIETY
BY M'CALLA & STAVELY.
1882.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

HELD AT PHILADELPHIA.

VOL. XIX. MARCH TO DECEMBER, 1880. No. 107.

Stated Meeting, March 19, 1880.

Present, 8 members.

Visitor, Mr Hampton L. Carson of Philadelphia.

Letters of envoy were received from the Central Physical Observatory at St. Petersburg, January, 1880; from the Royal Observatory at Greenwich, February, 1880, and from the Meteorological Society in London, February, 1880.

Donations for the Library were reported as received from the Asiatic Soc., Yokohama; Russian Academy; Botanische Central-blatt, Leipsig; Deutsche Rundshau für Geog. u. Stat., Munich; Belgian Academy; Geographical Societies at Paris and Bordeaux; the Revue Politique; Revista Euskara, Pamplona; British Association; Society of Antiquaries; Meteorological Council of the Royal Society, London; Natural History Society, Montreal; Museum of Comp. Zoöl. Cambridge, Mass.; Franklin Institute, Medical News, Dr. Alfred Stillé, Dr. C. P. Krauth, and Mr. Henry Phillips, Jr. of Philadelphia; Smithsonian Institution; Bureau of

Education; Engineer Department, Washington; Ministerio de Fomento, Mexico; and Prof. S. S. Haldeman.

Donation for the Cabinet.—Mr. Hampton L. Carson presented, on the part of his sisters and himself, in fulfillment of his father's wishes, to the cabinet of the Society, a portrait in oils of M. François André Michaux, the botanist, who died at Paris, October 23d, 1855, ætat 85.

Mr. Fraley returned the thanks of the Society for so interesting and valuable a relic of our distinguished fellow-member, who exhibited in his lifetime so great an attachment for the Society, and in his will such confidence in the honor of its traditions as to make it the trustee of a fund which he bequeathed for Silviculture in America.

Mr. E. K. Price also described the amicable relations which existed between M. Michaux and the Society, claiming the privilege of doing so on the ground that the Society had conferred on him the duty of carrying out the designs of M. Michaux according to the plan adopted by the Committee and approved by the Society, and sketched the principal features of that plan—the planting of the Michaux grove—and the organization of Prof. Rothrock's annual course of public lectures in the Park.

It was then on motion

Resolved, That the thanks of the Society be presented to Mr. Hampton L. Carson and his sisters for their gift of the portrait of M. F. A. Michaux whose liberal bequest to the Society is now so beneficially available for the promotion of Silviculture and Botany.

Resolved, That the Society appreciates the gift more highly because it has been made in compliance with the wish of the late Dr. Joseph Carson, one of its devoted and useful members, whose memory is endeared to his associates by many recollections of his worth and virtues.

Resolved, That a copy of these resolutions be transmitted to Mr. Carson.

The death of Dr. William Theodore Roepper, at his residence in Bethlehem, Pa., on Wednesday, March 10th, at the age of 70, was announced by Mr. Lesley.

On motion, Dr. F. A. Genth was appointed to prepare an obituary notice of the deceased.

The death of General Hector Tyndale, at his residence in

Clinton street, Philadelphia, on Friday, March 19th (3 A. M.), at the age of 58, was announced by Mr. J. S. Price.

A communication was received entitled "Nodal estimate of the velocity of Light," by P. E. Chase.

Mr. Phillips read a paper describing two very old and curious maps of North and South America.

Dr. Greene communicated a paper "On the action of hydrochloric acid and chlorine on acetobenzoic anhydride," by Wm. H. Greene, M.D.

Pending nominations Nos. 893 to 901, and new nominations Nos. 902 to 908, were read.

The publication of the proceedings at the late celebration of the Centennial Anniversary of the Incorporation of the Society was then discussed.

The Committee on the Michaux Legacy reported through its chairman, Mr. E. K. Price:

"That the appropriation made last year was applied to defray the expenses of fourteen lectures in the Horticultural Hall, Fairmount Park, by Dr. Rothrock. It was attended by more than previous members, varying from one to two hundred persons. Teachers in the public schools numerously availed themselves of this valuable opportunity of studying Botany.

"Dr. Rothrock feels it important to spend the later summer and autumn in Germany, in the pursuit of his studies. His course this year will be seven lectures, for which an appropriation is respectfully asked."

On motion an appropriation of one hundred and seventy dollars was made, from the income of the Michaux fund, for defraying the expenses of the seven lectures of Prof. Rothrock, and advertising the same. On motion of Mr. Price it was

Resolved, That one hundred dollars ($100) be appropriated out of the income of the Michaux fund, for a copy of the Michaux portrait, and frame, to be presented to the Park Commissioners, to be put in the Horticultural Hall, standing in the Michaux grove, where our Michaux lectures are delivered by Dr. Rothrock; and the Michaux Committee attend to the subject.

An appropriation of forty dollars ($40) was, on motion, made to defray the expense of an illustration for Mr. Ashburner's paper on Oil Sands in the printed Proceedings.

Mr. Fraley then stated that as the Society had left it with

him to appoint delegates to Boston, he requested the Secretaries to send information to each of the Board of Officers and to Dr. R. E. Rogers and to Mr. Wm. A. Ingham that he nominated them as delegates to represent this Society and assist on the 26th of May at the Centennial Celebration of the American Academy of Arts and Sciences in Boston.

The meeting was then adjourned.

Astronomical Approximations. IV. Nodal Estimation of the Velocity of Light. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, March* 19, 1880.)

The accuracy of my approximation to the apparent semi-diameter of the Sun* is confirmed by the following kinetic considerations, some of which, though seemingly of great fundamental importance and character, have been generally overlooked.

1. Matter has been usually regarded as composed of discrete particles. This hypothesis enters even into the kinetic theory of gases. If it is true, all force must be transmitted from particle to particle and time must, therefore, be required to overcome the inertia of masses.

2. Attraction and repulsion have been generally considered under the influence of central forces, varying inversely as the squares of the distances from the centres and, therefore, producing motions with variable velocity.

3. Waves, orbital undulations, and other cyclical motions, are generally propagated with uniform or nearly uniform velocity, although they are often accompanied by subordinate movements with varying velocity. Variable velocities are often converted into uniform or nearly uniform velocities, as in the case of conical pendulums, planetary rotations and orbital revolutions.

4. In all undulations, and in all cyclical motions through an undulating medium, there are tendencies to synchronism. The synchronism may be complete, producing equal cyclical motions in equal cyclical times; or nodal, producing harmonic series of cyclical motions which are completed in equal times.

5. Newton showed that if a centripetal force varies as the distance of a body from the centre, all bodies, revolving in any planes whatsoever, will describe ellipses and complete their revolutions in equal times; † that bodies which move in right lines, running backwards and forwards alternately, will complete their several periods of going and returning in the

* Proceed. Am. Phil. Soc. xviii, 380.

† Principia, B. I, Prop. 47

same times ;* and that if a fluid be composed of particles mutually repelling each other, and if the density varies as the compression, the centrifugal forces of the particles will be reciprocally proportional to the distances of their centres,† as if indicating a reaction against a force which varies as the distance from the centre. The centripetal force is partially illustrated by the rotation of planetary bodies; the centrifugal, by the varying pressure of elastic atmospheres.

6. Such centripetal force as is above supposed, requires, for its complete manifestation, an omnipresence of activity, which is devoid of inertia, of ponderability, and of all other ordinary tests of material nature ; an activity which may, perhaps, properly be regarded as spiritual.

7. Laplace found himself obliged to recognize an activity in gravitation, which is propagated with at least 100,000,000 times the velocity of light.‡ This activity, he says, may be properly regarded as instantaneous. If it is spiritual, it may without difficulty be regarded as absolutely instantaneous throughout the universe. If it is material, it is difficult to conceive of any relation of elasticity to density which would be so great as 10,000,000,000,000,000 times that of the supposed luminiferous æther. Yet such are the requirements of the Newtonian law, that "the velocities of pulses propagated in an elastic fluid are in a ratio compounded of the subduplicate ratio of the elastic force directly, and the subduplicate ratio of the density inversely." § The importance of this law has been shown by the investigations of Graham, by the inquiries of English and German physicists into the relations between electromagnetic and luminous velocities, and by my own correlations of the force of solar rotation with the forces of light, gravitation and chemical attraction.

8. In any elastic or quasi-elastic medium, "if the distances be taken in harmonic [or arithmetical] progression, the densities of the medium at those distances will be in a geometrical progression." ‖ I use the term "quasi-elastic," in order to meet the views of Faraday, Preston ¶ and others, who prefer to treat all kinetic questions in accordance with lines of force.

9. The distances of projection, under uniform resistance, are proportioned to the living forces of projection, and inversely as the density of the resisting medium.

* Principia, B. I, Prop. 47.
† Ib. B. II, Prop. 23.
‡ Mec. Cel., X, vii, 22.
§ Principia, B. II, P. 48.
‖ Ib., B. II, P. 22.
¶ P. Mag., June, Sept., 1877. Preston does not give Maxwell's demonstration of the ratio $\sqrt{\frac{5}{9}}$, and neither he nor Maxwell seems to have been aware that I had used the same ratio of *vis viva* five years previously, in discussing results of gaseous energy (Proc. Am. Phil. Soc. Feb. 16, 1872, vol. xii, p. 394, foot-note). I showed that in the explosion of gases, the secondary centre of oscillation, on the return towards the centre, is at $\left(\frac{12}{18} - \frac{2}{3} \text{ of } \frac{12-9}{18} = \frac{5}{9}\right)$ of the extreme excursion.

10. In most, if not in all, physical investigations which introduce considerations of central force, velocity may be treated as a function of radius, time and mass.

$$v = F(r,\ t, m).$$

In undertaking to investigate successive conversions of spiritual, undulatory, and centripetal or centrifugal energy, astronomical phenomena furnish the most abundant, extensive, and varied opportunities for observation and illustration. Unfortunately, there is so much uncertainty in regard to the dimensions and densities of the principal heavenly bodies, that we can point to few results which are so precise as would be desirable. There are, however, some important indications of the operation of the foregoing laws, which are confirmed by terrestrial phenomena that are capable of very accurate measurement.

In Searle's Outlines of Astronomy, page 403, the following figures are quoted from the *Annalen der Sternwarte in Leiden*, on the authority of Kaiser. "The apparent diameter of Mercury, at a distance equal to the semi-axis major of Earth's orbit, ranges, according to different observers, from 5″.2 to 6″.9 ; that of Venus from 16″.6 to 17″.9 ; the apparent equatorial diameter of Mars from 9″.6 to 9″.2 ; its apparent polar diameter from 9″.4 to 9″.2. Similar disagreements appear in different estimates of the apparent diameters of Jupiter, Saturn, Uranus, and Neptune, at a distance for each planet equal to the semi-axis major of its orbit. Thus the equatorial diameter of Jupiter ranges from 39″.5 to 37″.1 ; its polar diameter from 37″.9 to 35″.1 ; the equatorial diameter of Saturn from 18″.5 to 16″.9 ; its polar diameter from 16″.8 to 15″.1 ; the diameter of Uranus from 2″.9 to 3″.6 ; that of Neptune from 2″.5 to 4″.4."

Kaiser adopts, as most probable values for the ratios of the several diameters to Earth's diameter, figures which I have increased by one per cent., in order to adapt them to more recent estimates of Sun's distance. These increased figures are given under r(I), in the following table. Under r(II) and in the subsequent columns, I give theoretical values which illustrate simple harmonic deductions from the above general function of velocity.

	Mass-denominator.	r(I).	r(II).	ρ.		g.	δ.
1. Mercury,	4865751	.34	.36	.387	$\rho^{\frac{2}{3}}$	$=$ .53	1.484
2. Venus,	427240	.97	.98	.723	$\rho^{\frac{2}{3}}$	$=$ .81	.822
3. Earth,	330985	1.00	1.00	1.000		1.00	1.000
4. Mars,	3093500	.53	.53	1.524	$\frac{1}{4}\rho$	$=$ .38	.719
5. Jupiter,	1047.88	11.04	11.02	5.203	$\frac{1}{2}\rho$	$=$ 2.60	.236
6. Saturn,	3501.6	9.10	9.20	9.539	$\rho \div \rho_1$	$=$ 1.12	.121
7. Uranus,	22600	3.60	3.60	19.184	$\rho \div t$	$=$ 1.13	.314
8. Neptune,	19380	5.80	5.84	30.034		.50	.086
9. Sun,	1	109.11	109.05			27.83	.255

The value which I have assumed for Earth's mass is the one which I have deduced from velocities of rotation and revolution and Struve's constant of aberration. The other mass-denominators are the ones which are

now generally adopted by astronomers. The semi-axes major are represented by ρ; the superficial equatorial acceleration of gravity, by g; the density, by δ; Earth's values being assumed as the units. In the expressions for g of Saturn and Uranus, $\rho_1 = 3.539$; $t = 16.9823$; ρ_1 being the mean distance between the centre of the belt of greatest condensation (Earth) and the primitive centre of rotary inertia (Saturn); t being the ratio between the time of Earth's rotation (a sidereal day) and the limiting time of satellite-revolution $\left(2\pi\sqrt{\frac{r}{g}}\text{, at Earth's equatorial surface}\right)$. It is impossible, at present, to assign any more probable values for the planetary radii than those which I have given under r(II). From those values and the masses, g and δ are readily found by the proportionalities, $\delta \propto m \div r^3$; $g \propto m \div r^2$. The relations of g to simple functions of the semi-axis major would be very striking, even if they were only approximately true. Although we cannot ascertain whether the relations are exact or not, the following considerations seem to increase the probability that they are correct indications of normal harmonic modifications of gravitating force by distance and time.

In comparing the gravitating force at the principal centres of early nebular activity, we may, then, acknowledge a strong probability:

1. That the force at the centre of reciprocity (Neptune), is one half as great as at the centre of the belt of greatest density (Earth).

2. That the force at the centre of rotary inertia (Saturn), is to the force at the centre of density, as the rotary centripetal force at Sun, is to the rotary centripetal force at Earth, the rotating tendencies being referred to Saturn as a centre.

3. That the force at the centre of nebulosity (Jupiter), is to the force at the centre of density, as the combined influence of the gravitating force at the centre of reciprocity and the rotary centripetal force at Jupiter, is to the combined influence of the corresponding forces at Earth.

4. That the force at the centre of nucleation (Sun), is equal to the velocity of light, divided by the time of a half-rotation; the half-rotation indicating the alternate oscillation of equatorial particles, from and towards the centre of gravity of Sun and Jupiter.

In extending the comparison to the subordinate centres within the belt of greatest condensation, we find a like probability;

5. That the force at Mars is to the force at the centre of density, as the combined force of gravitating *vis viva* at the centre of reciprocity and rotary centripetal force at Mars, is to the corresponding combined influences at Earth.

6. That the force at each of the inferior planets (Venus and Mercury), is represented by the ratio of projectile living forces to times of revolution.

Leaving the outer and somewhat doubtful territory, and entering upon surer ground, let us consider some of the obvious results of conversion of primitive force, with reference to centres of condensation.

1. If the velocity is constant, the radius of rotation or revolution must be proportioned to the time.

2. If radii, which were originally established by a constant velocity, are converted into radii of free revolution under equivalent central forces, the times of revolution must be proportioned to the $\frac{3}{2}$ power of the radii.

3. If radii of synchronous revolution and axial rotation are due to the action of a primitive constant wave-velocity, while nucleal radii are due to the collision of particles moving with parabolic velocity, the former velocity would be communicated in the time of a half-rotation, while the latter would be communicated in $\frac{\sqrt{2}}{\pi}$ of the same time.

4. Let us suppose that the ratio of the solar year to the terrestrial day originated in the constant velocity (1) of light, which is still represented by the equation of solar half rotation $\left(\frac{gt}{2} = v_\lambda\right)$; that the time-radii (r_t) were converted into radii of free revolution under equivalent central forces (2); and that corresponding nucleal radii (ρ_t) were established by parabolic collision (3). We should then have

$$\left(\frac{r_t}{\rho_t}\right)^{\frac{3}{2}} = \frac{\pi}{\sqrt{2}}$$

or, substituting the ratios which are represented by r_t and ρ_t,

$$\left(\frac{1 \text{ year}}{1 \text{ day}}\right)^{\frac{3}{2}} : \left(\frac{\text{Earth's semi-axis major}}{\text{Sun's semi diameter}}\right)^{\frac{3}{2}} : : \pi : \sqrt{2}.$$

The sidereal year is composed of the original nebular sidereal rotation and the 365.25636 additional sidereal rotations which are due to terrestrial condensation. Making these substitutions,

$$\left.\begin{array}{l} (365.25636)^{\frac{3}{2}} : x^{\frac{3}{2}} : : \pi : \sqrt{2} \\ x = 214.5365 \end{array}\right\} \ldots\ldots\ldots\ldots\ldots\ldots \text{A.}$$

Among the obvious nodal influences of distance and velocity which may be reasonably supposed to have modified the kinetic undulations between the centres of density and of nucleation, the following may be specified :

1. The velocity of light, V_λ, or the projectile velocity which is equal to the sum of Sun's gravitating equatorial reactions during a half rotation, $\frac{gt}{2}$.

2. Sun's limiting velocity of revolution, $V_0 = \sqrt{gr}$, r being the equatorial radius.

3. Earth's limiting velocity of revolution, $v_0 = \sqrt{gr}$, at the equatorial surface.

4. Earth's superficial equatorial velocity of rotation, v_r.

5. Earth's semi axis major, ρ_e.

6. Earth's diameter, $2r$, or the major-axis of limiting synchronous linear, elliptical and circular oscillation.

7. Moon's semi-axis major, ρ_1.

8. The ratio of variation between Laplace's limit, r_1, and the nucleal radius, r_0; $r_1 \propto r_0^{\frac{3}{2}}$.

From Struve's constant of aberration, equation A, and other well-known measurements, we find: $V_\lambda = 214.5365 r_0 \div 497.827 = .4309438 r_0$; $V_0 = 214.5365^{\frac{3}{2}} \times 2\pi r_0 \div 31558150 = .00062564 r_0$; $v_0 = \left(\frac{3962.82 \times 32.088}{5280}\right)^{\frac{1}{2}} = 4.9075$; $v_r = 2\pi \times 3962.82 \div 86164 = .288974$; $V_\lambda \div V_0 = 688.815$; $v_0 \div v_r = 16.98237$. The combined nodal action of V_λ, V_0, v_0, v_r, ρ_0 and $2r$ are represented by the equation:

$$\left.\begin{array}{l}
\dfrac{V_\lambda}{V_0} + \dfrac{v_r}{v_0} = \dfrac{\rho_0}{2r} \\
688.815 \times 16.98237 = \rho_0 \div 7935.64. \\
\rho_0 = 93{,}711{,}850 \text{ miles.} \\
V_\lambda = \rho_0 \div 497.827 = 186{,}233 \text{ miles} = 299{,}705 \text{ kilometers.} \\
r_0 = \rho_0 \div 214.5365 = 432{,}495 \text{ miles.} \\
\rho_0 \div r = 23{,}395.4. \\
\dfrac{\text{Sun's mass}}{\text{Earth's mass}} = 330{,}997.
\end{array}\right\} \quad \text{.........B.}$$

If we adopt Newcomb's estimates of Sun's diameter, mass and distance (*Popular Astronomy*, p. 528), the nodal value of V_λ would be 185,334 miles; the value as determined by Struve's constant of aberration, 185,475 miles; the discrepancy being only $\frac{1}{13}$ of one per cent. Michelson's estimate (299,820 km.) is about $\frac{1}{28}$ of one per cent. greater than mine, and about $\frac{1}{2}$ of one per cent. greater than Newcomb's.

Newton's law of the ratio of elastic densities to distances (8), the law of projection under uniform resistance (9), and the ratio of variation between Laplace's limit and the nucleal radius, all are illustrated by the lunar equations:

$$\left.\begin{array}{l}
\dfrac{v_0}{v_r} \times \dfrac{32}{9}\, r = \rho_1 = 60.3815 r. \\
\left(\dfrac{v_0}{v_r}\right)^{\frac{32}{9}} r = \rho_0 \textit{ very nearly} = 23{,}622 r.
\end{array}\right\} \quad \text{...............C.}$$

J. J. von Littrow's estimate for Moon's semi-axis major, cited by Searle (p. 406), is 60.2778, or about $\frac{17}{100}$ of one per cent. less than the above result. The velocity of light, as deduced from the lunar value of ρ_0, is 188,040 miles, or nearly one per cent. greater than the value found in equations B.

I think no one will be likely to attach much weight to the larger value, but it is interesting on account of its indication of elliptical nebular influence, with a nucleal radius about one per cent. larger than Sun's present radius, and a major axis about one per cent. larger than Earth's present mean vector-radius. The nebular influence may be inferred from the fact that $\frac{32}{9} = 2 \times \left(\frac{4}{3}\right)^2$.

An Account of Two Maps of America Published Respectively in the Years 1550 *and* 1555. *By Henry Phillips, Jr., A.M.*

(*Read before the American Philosophical Society, March* 19, 1880.)

I.

In the *Cosmographia Universalis* of Sebastian Munster, published at Basle, in 1550, there occurs a large two page map of the New World which is so quaint, so singularly inaccurate, yet with all its faults so suggestive that a description cannot fail to be of interest to all who care to retrace the early history of our country.

The copy of Munster which is in the library of our Society is the German edition of 1563, but contains the same illustrations and maps that occur in the earliest copies of the work. As reprints took place, no changes seem to have been made in the letter-press, and certainly no alterations were effected in the charts and engravings.

North and South America are represented as a large island joined together, where Central America now exists, by a strip of land. All the upper boundary of North America is water. The coast line from what is now called Labrador and New Brunswick to the Gulf of Mexico is not badly outlined; Canada receives the name of *Francisca;* Yucatan is figured as a large island directly west of Cuba, which latter lies immediately to the south of the peninsula now known as Florida. The *Tortugas* islands are thrown far into the bosom of the Gulf of Mexico, to which body of water no name is assigned. Mexico itself appears as *Chamaho*, and a small island, *Panuco*, is represented near this country, off the mouth of a large river. Jamaica, spelled *Jamica*, lies to the south of Cuba; Hispaniola, directly to the east.

At the point where South America is joined to the Northern Continent is a country which bears the name of *Parias*, marked, "*abundat auro et margaritis.*" The configuration of Mexico is but poorly preserved, and the Pacific coast is dotted with random indentations of rivers and bays. Lower California does not appear, nor yet the Gulf which separates it from Mexico.*

A very large body of water, a continuation of that which forms the boundary of the Northern Continent, in shape and position not unlike to Hudson's Bay, stretches far down to within a short distance from the sea-coast, no great way off from the present site of New York city, New York. Probably this was placed upon the map in conformity with Indian reports of vast interior bodies of water, confusing the Great Lakes of the Northwest, with Hudson's Bay.

The peninsula now known as Florida is quite correctly drawn, although it does not bear any name, but a region of country corresponding

* According to Humboldt, Lower California had been recognized as a peninsula as early as 1539–41.

with the south-western parts of North Carolina, the north-western and northern portions of Georgia, the upper portions of Alabama and Mississippi, and the lower parts of Tennessee, receives the appellation of *Terra florida*. Above this region and trending to the north is a range of mountains, from whose western extremity a very large but nameless river takes its rise, in two diverging branches, at a considerable distance from the sea-coast, and ultimately empties its waters into the Gulf of Mexico. This seems to represent the Mississippi, and is in a reasonably accurate position, except that the junction of the two streams which compose it, is placed too near the river's mouth.* It is possible that some tradition of the Missouri may appear in the north-western branch of this stream.

To the west some distance off, is a large but nameless river taking its rise in a range of mountains which run from east to west. This may be the Rio Grande del Norte, the Texan boundary line.

The Isthmus of Central America is delineated as somewhat larger than it really is. South America is very incorrectly drawn, being too "squat" in appearance. A large river empties on its northern shores into the ocean, and on the land, at the easternmost projection of the Continent there stands a hut constructed of boughs, leaves and branches, from one of which latter a human leg is pendant. Lest there should be any doubt in the mind of the reader as to what all this meant, the word *Canibali* is printed upon this region to show the nature of its inhabitants. The bay of Rio Janeiro, although nameless, is shown, but appears to penetrate much farther into the main land than it really does. At the mouth of this reach of water are islands bearing the name 7 *insulæ Margueritarum*.

Farther to the south is a country marked *Regio Gigantum*, and still lower is the *Fretum Magellani*, separating the Southern Continent from a piece of land, whose termination is not shown on the map.

The configuration of the western coast is still more defective. Only one name appears on it, *Catigara*, which is far up towards the north-west. Printed upon the South American Continent are the words, "NOVUS ORBIS, *nova insula Atlantica quam vocant Brasilii et Americam.*"

The Western portion of the map is filled by the MARE PACIFICUM, in the lower part of which is drawn an old-fashioned, high-pooped, one-masted vessel, above which is the island *Zipangri* surrounded by ARCHIPELAGUS 7448 INSULARUM.

In the extreme north-west of the map is *India superior*, which contains *Cathay*, and its capital city, *Quinsay*. Below the ship are the *insulæ infortunatæ*.

II.

I turn from this map to one which, although published five years later, was evidently engraved at some very much earlier date.

The Novus Orbis of Simon Grynæus, published at Basle, in 1555, con-

*The Mississippi was discovered by De Soto in 1541, but the account of his travels was not published till 1557.

tains what was intended for a representation of the world as then known. It is a very large map, surrounded by a border of wood-cuts, very similar in subject and treatment to those found in Munster, exhibiting cannibals, wigwams, serpents, elephants, &c. Within the border are the names of various winds, and upon the seas are delineated remarkable monsters, fish and mermaids.

The portion of the map upon which America appears is the only one which will claim our attention.

North of Cuba there is no land whatever. This island is represented in the form of a parallelogram extending from Latitude 10° to Latitude 49° North, and lying between Longitude 280° and 290° East from the meridian of Madeira. At its southern extremity flows a narrow strait which separates it from South America, called on the map, AMERICA, TERRA NOVA. The shape of the upper portion of the Southern Continent is not badly preserved, but as it descends it becomes thinner and thinner, ultimately closing in a point of land without any suggestion whatever of the Straits of Magellan. On the northern coast are the *Canibali*, at the west is *Parias*, about Latitude 20° South is *Brasilias*. An island marked *Terra cortesia* almost due west of the northern extremity of Cuba lies in Longitude 310° E and Latitude 50° N. To the south-east of the centre of Cuba, lying between Latitude 20° and 30° North and Longitude 300° and 310° East, is an island called *Isabella;* east and south of this are a cluster of islands designated as *Insulæ Antigliæ*, through which the Tropic of Cancer passes, and just above *Spagnolla*, which is to the south of Cuba.

This comprises all the land shown in the Western Hemisphere except the island of *Zipango*, due west of the centre of Cuba, in Latitude 10° to 30° N., Longitude 260° to 270° East.

The ocean between Europe and Cuba is called *Oceanus Magnus*.

NOTE.—The inaccuracy of this map is really surprising, when we consider the facilities then already in existence for verification. A Spanish *mappa mundi* and hydrographic chart published in 1573 (Lelewel. I. p. CXXXVI), presents the North American coast not badly delineated from Newfoundland down, although exhibiting some uncertainty. The Peninsula of Florida appears under that name, and Lower California is separated from Mexico by a body of water, and Mexico and Central America are quite correctly drawn. Yucatan is shown as a peninsula, and in its proper position. The conformation of the Gulf of Mexico is reasonably accurate. South America is justly drawn, although the portion below the Straits of Magellan is only partially exhibited. The *Canibales* still are attributed to the northern part of Brazil.

The Amazon river appears under that name.

On the Action of Hydrochloric Acid and of Chlorine on Acetobenzoic Anhydride. By *Wm. H. Greene, M.D.*

(*Read before the American Philosophical Society, March* 19, 1880.)

In September last, M. Loir published, in the *Bulletin de la Société Chimique*, a paper upon the double function (alcohol and aldehyde) of various acids and anhydrides. I will not discuss the general conclusions of this article, which has found its way into many of the collections of scientific literature, but the paper contains grave errors upon certain of the reactions of acetobenzoic anhydride. According to M. Loir, this compound behaves differently with hydrochloric acid and with chlorine, accordingly as it has been prepared by the action of acetyl chloride upon sodium benzoate, or of benzoyl chloride upon sodium acetate. Made by the last of these processes, it is decomposed by hydrochloric acid at 130°, into acetyl chloride and benzoic acid: chlorine at 140° converts it into acetyl chloride and chlorobenzoic acid. Under the same circumstances, the anhydride prepared by the first process is unaffected, but at 160° hydrochloric acid converts it into benzoyl chloride and acetic acid; at 170° under the action of chlorine it yields benzoyl chloride and chloracetic acid.

Acetobenzoic anhydride begins to decompose at a temperature below 150°, into acetic anhydride and benzoic anhydride, and at temperatures near this point it should act as would a mixture of the latter two bodies. Under the influence of hydrochloric acid it should yield acetyl chloride, acetic acid, benzoyl chloride and benzoic acid. Chlorine should act in an analogous manner. I have repeated the experiments of M. Loir, with the following results:

If dry hydrochloric acid be passed into acetobenzoic anhydride, at ordinary temperatures, the reaction is the same, by whichever process the anhydride may have been prepared: benzoic acid is deposited, and the tube conveying the hydrochloric acid becomes obstructed. On raising the temperature, acetyl chloride begins to distill at 55–60°, and the product obtained up to 130° is a mixture of acetyl chloride and acetic acid. If the heat be raised much above 130°, and if the current of hydrochloric acid be rapid, a small quantity of benzoyl chloride is carried over, and will be found in the distillate. The residue in the apparatus consists of benzoyl chloride and benzoic acid. If the anhydride be heated to 130°, or any other temperature, before passing the hydrochloric acid, the reaction is the same with the anhydride prepared by each process. However, it seems that the lower the temperature the greater the proportions of acetyl chloride and benzoic acid which are formed, while at higher temperatures (130–150°), the reaction yields acetyl chloride, acetic acid, benzoyl chloride and benzoic acid in about equivalent proportions.

Chlorine acts in an analogous manner: the products are the same in whichever manner the anhydride may have been prepared; but, with the exception of the acetyl chloride, these products are more difficult to

separate than those formed in the reaction with hydrochloric acid. Indeed, chloracetic acid boils at about 186°, and benzoyl chloride at 198°: in the experiments of M. Loir, the latter compound seems to have distilled over first, leaving the chloracetic acid in the retort. At temperatures near 150°, the products of this reaction are acetyl chloride, chloracetic acid, benzoyl chloride and chlorobenzoic acid; at lower temperatures, the principal products are acetyl chloride and chlorobenzoic acid.

From his experiments, M. Loir considers that there is a difference in constitution between benzoyl acetate and acetyl benzoate, but the results of these experiments being erroneous, such a conclusion is unsustained. These bodies thus named are identical; all of their reactions *under the same conditions* are the same, and they must be represented by the same rational formula.

Stated Meeting April 2, 1880.

Present, 12 members.

Mr. Fraley, Prof. P. E. Chase, Dr. R. E. Rogers, Mr. J. S. Price, Dr. Cresson, and Mr. Phillips signified by letter their acceptance of the appointment to represent the Society at Boston on the 26th of May.

Dr. Genth declined the appointment to prepare a notice of the late Prof. Roepper, on the score of ill-health.

A letter of envoy was received from the U. S. Naval Observatory in Washington.

A letter requesting contributions to the burnt library at St. John, New Brunswick, was received from Mr. Jas. Domville, Honorary Secretary, House of Commons, Canada, dated Ottawa, March 11, 1880.

Donations for the library were received from the Academies at Rome, Berlin, Brussels, and Philadelphia; the Geographical Society at Bordeaux; the Victoria Institute, R. Astronomical Society, and London Nature; the Societies at Quebec and Milwaukee; the Boston Natural History Society; Cambridge Museum C. Z., and New England Genealogical Society; the Observatories at Washington and Mexico; the University and Peabody Institute at Baltimore; Mr. J. S. Price, and Mr. Henry Phillips, Jr.

The death of Guillaume Philippe Schimper, at Paris,

March 29, aged 72, was announced by the Secretary; and on motion, Prof. Leo Lesquereaux of Columbus, O., was appointed to prepare an obituary notice of the deceased.

A short communication "On the origin of planets" was received from Prof. Daniel Kirkwood.

Pending nominations Nos. 893 to 908 and new nominations Nos. 909 to 913 were read.

On motion of Mr. J. S. Price, based upon a letter from Dr. Cattell of Easton, the use of the Hall of the Society was tendered to the American Philological Association for its next annual meeting in July.

And the meeting was adjourned.

On the Origin of Planets. By Daniel Kirkwood.

(Read before the American Philosophical Society, April 2, 1880.)

If Laplace's hypothesis of the formation of planets and satellites from nebulous *rings* cannot be sustained* we may conclude that each planet, at its origin, was separated from a very limited arc of the equatorial protuberance; or, in other words, that instead of the separation of a ring, the centrifugal force produced a rupture at the point of least resistance in the equatorial belt. From the chasm thus formed a nebulous mass was thrown out, which in process of time was transformed into the outermost planet.† The tendency to separation around the equator would thus be relieved, and the ellipticity of the spheroid temporarily diminished. Further condensation, however, would again increase the centrifugal force until another rupture or outrush similar to the first would necessarily result. The formation of planets from these nebulous masses may thus be explained without the necessity of supposing such matter to have been slowly collected from continuous rings.

The origin of satellites is also very obviously accounted for. In short, where the ring hypothesis is encumbered with difficulties well nigh insuperable, the theory here proposed seems less open to objection. Not improbably, however, the ancient orbits of the secondary systems and perhaps also of some of the primary planets may have differed to a considerable extent from their present dimensions, as is shown by Mr. G. H. Darwin in his "Tidal Theory of the Evolution of Satellites."‡

* Proc. Amer. Phil. Soc., vol. xviii., p. 324.

† It is now believed by astronomers that the phenomena of temporary stars, such as those of 1572, 1866 and 1877, are produced by enormous outbursts of incandescent matter.

‡ The Observatory for July, 1879.

Stated Meeting, April 16, 1880.

Present, 17 members.

President, Mr. FRALEY, in the chair.

A letter of acknowledgment was received from the K. K. Central Anstalt für Meteorologie und Erdmagnetismus, at Vienna, dated March 17, 1880 (100, 103).

A letter of envoy was received from the Surveyor-General of India, dated Calcutta, March 1, 1880.

Donations for the Library were received from the Swedish Bureau of Statistics, Stockholm; Herr C. A. Dohrn, Stettin; the editor of the "Zoologischer Anzeiger," Leipsig; the Royal Academy, Brussels; Société de Géographie, and Révue Politique et Litteraire, at Paris; Accademia dei Lincei, Rome; Editors of the "Revista Euskara," Pamplono; Society of Antiquaries, Editors of Nature, and Mr. Joseph Prestwich, London; Natural History Society, Montreal; Connecticut Academy of Arts and Sciences, and American Journal of Science, New Haven; Trustees of the Astor Library; Editor of the North American Entomologist, Buffalo; New Jersey Historical Society; New Jersey State Geologist; Franklin Institute, Medical News, American Journal of the Medical Sciences, and American Journal of Pharmacy, Philadelphia; the Managers of Haverford College, Penna.; Mr. Henry Phillips, Jr., of Philadelphia; Cincinnati Society of Natural History; St. Louis Academy of Sciences; and M. Hugo von Meltzl.

No. 105 of the Proceedings of the Society, just published, was exhibited.

Mr. Lesley communicated the following extracts from a letter received from Mr. Lesquereux respecting an interesting discovery of North Carolina Triassic (?) plants in Bucks county, Pennsylvania:

"Yesterday (April 18) I found in a box, which I received about two weeks ago, a letter from Mr. John S. Ash, of Buckingham, Bucks county, Pennsylvania, with six specimens bearing vegetable remains of a Cycad: *Pterophyllum robustum* Emmons (a large specimen); *Calamites arenaceus* Brgt. (four specimens), outside and inside cylinder in two small specimens; a fragment of bark (undeterminable) like a *Cyclostigma*.

"These specimens, especially the *Pterophyllum*, are positively of the age of the Red of North Carolina, which Emmons refers to the Trias, and which White puts as high as the Lias or Jurassic; certainly not New Red as marked in the letter; still less Carboniferous.

"Neither Dana nor Rogers have seen this Formation in Pennsylvania, at least not in Bucks County. The fossils interest me very much.

Prof. Chase communicated three notes entitled:—

1. Astronomical Approximations. V. Cometary Paraboloids. 2. VI. Cosmical Determination of Joule's Equivalent. 3. Relations of Chemical Affinity to Luminous and Cosmical Energies.

Mr. Hall discussed some geological casts of a series from the State Geological Survey.

Pending nominations Nos. 893 to 908 were read and acted upon.

Pending nominations Nos. 909 to 913 were read.

Mr. Chase moved that Haverford College be placed on the roll to receive the publications (Proceedings and Transactions) of the Society. It was so ordered.

On scrutiny of the ballot boxes by the President, the following persons were declared duly elected members of the Society:

893. Dr. Austin Flint, Sr., of New York City.
894. Dr. Austin Flint, Jr., of New York City.
895. Dr. Roberts Bartholow, of Philadelphia.
896. Mr. J. Vaughn Merrick, of Philadelphia.
897. Mr. Horace Howard Furness, of Philadelphia.
898. Mr. Ellis Yarnall, of Philadelphia.
899. Rev. George Dana Boardman, of Philadelphia.
900. Mr. William B. Rogers, Jr., of Philadelphia.
901. Prof. Ogden N. Rood, of New York City.
902. Mr. Henry Martyn Chance, of Philadelphia.
903. Dr. William Thompson, of Philadelphia.
905. Mr. Carlisle P. Patterson, of Washington
906. Mr. Hampton L. Carson, of Philadelphia.
907. Mr. Joseph C. Fraley, of Philadelphia.
908. Rev. Joseph A. Murray, D.D., of Carlisle, Pa.

And the meeting was adjourned.

Astronomical Approximations. V., VI. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(Read before the American Philosophical Society, April 16, 1880.)

V. *Cometary Paraboloids.*

Some recent communications to the French Academy, by MM. Gaussin* and Faye,† have led me to re-examine some of my earlier discussions of the influence of projectile forces and perifocal collisions, upon nebular rupture and cosmical nucleation.‡ I have embodied some of the results of this examination in a comparison of my application§ of the general equation

$$x_n = \xi\eta^n\zeta^{n^2} \text{..} (1)$$

with Gaussin's analogous equation ‖

$$a = a\,k^n \text{..} (2)$$

If we let $r_0 = 1 =$ Sun's radius; $\xi = 16.164$; $\eta = 1.6252$; $\zeta = 1.013$, equation (1) gives a series of paraboloidal abscissas which represent important cosmical relations.

Bodies falling towards the centre of a cosmical system, from a distance nd, acquire the d-velocity of revolution, $(\sqrt{gd})$, at the distance $\frac{nd}{n+1}$.

Therefore, $\frac{d_0}{2}$, $\frac{2d_1}{3}$, $\frac{3d_2}{4}$, . . . represent points at which nebular subsidence would tend to produce rupture, with consequent orbital revolution at d_0, d_1, d_2 . . .

In Table I, P represents Stockwell's values for the secular perihelion points of rupture, in units of r_0; A, the values for secular aphelion; T, the theoretical rupturing distances as determined by equation (1).

TABLE I.

			P.	T.	A.
$\frac{1}{2}$ Mercury	=	$\xi\eta^2\zeta^4$	31.91	44.94	51.14
$\frac{1}{2}$ Venus	=	$\xi\eta^3\zeta^9$	72.11	77.91	83.07
$\frac{2}{3}$ Earth	=	$\xi\eta^4\zeta^{16}$	133.34	138.58	152.71
$\frac{3}{4}$ Mars	=	$\xi\eta^5\zeta^{25}$	210.96	252.93	279.38
$\frac{4}{5}$ Ceres	=	$\xi\eta^6\zeta^{36}$	438.66	473.69	511.84
$\frac{5}{6}$ Jupiter	=	$\xi\eta^7\zeta^{49}$	873.59	910.30	986.75
$\frac{6}{7}$ Saturn	=	$\xi\eta^8\zeta^{64}$	1606.19	1795.05	1902.03
$\frac{7}{8}$ Uranus	=	$\xi\eta^9\zeta^{81}$	3319.21	3632.14	3881.96
$\frac{8}{9}$ Neptune	=	$\xi\eta^{10}\zeta^{100}$	7408.37	7541.32	7626.46

* Comptes Rendus t. xc, pp. 518, 593.

† Ib., p. 593.

‡ Proc. Am. Phil. Soc. Vols. ix—xii.

§ Ib. xii, 520.

‖ Loc cit, p. 520. Equation (2) is a special case of equation (1), with $\zeta = 1$.

The perihelion and aphelion values for ⚳ Ceres were found by taking Newcomb's value for the eccentricity (.077) and mean distance ($2.769 \rho_3 = 594.06 r_0$). The other values of P and A are computed from Stockwell's elements of planetary distance and secular variation, taking $214.54 r_0$ for the value of Earth's semi-axis major (ρ_3).

Dividing the values of T, in Table I, by the respective rupturing co-efficients ($\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{4}$, . . .), and reducing to units of Earth's semi-axis major, we obtain the values in column C, Table II, for comparison with Gaussin's values, which are given in column G.

TABLE II.

	P.	C.	G.	A.
Mercury	.297	.419	.362	.477
Venus	.672	.726	.623	.774
Earth	.932	.969	1.073	1.068
Mars	1.311	1.572	1.848	1.736
Asteroid	2.182	2.760	3.188	2.954
Jupiter	4.886	5.092	5.483	5.519
Saturn	8.734	9.761	9.445	10.343
Uranus	17.681	19.348	16.269	20.679
Neptune	29.598	30.120	28.025	30.470

The perihelion and aphelion values of the asteroidal belt are represented by the mean distances of ([illegible]) and ([illegible]). All the other values in columns P and A are computed from Stockwell's elements. Gaussin's approximations to the distances of Venus, Earth, Mars, Uranus, and Neptune, are all outside of the limits of secular excursion for those planets respectively. My own values are all within those limits, and their approximations to the mean values are closer than those of any other similar series that has ever fallen under my notice.

The data for the construction of the cosmothetic paraboloid were derived from considerations of linear oscillation (α), *vis viva* (β, δ), nucleal rotation and synchronous orbital revolution (γ), spherical oscillation (δ), inter-stellar actions and re-actions of projection and attraction (ϵ), luminous undulation (ζ) and universal nebular subsidence and rupture (η).

α. The focus of paraboloidal action is Sun's centre. The locus of the directrix is also the locus of the linear centre of oscillation of Sun's diameter, referred to Sun's surface ($\frac{2}{3} d - r = \frac{1}{3} r$).

β, *γ*. The fundamental abscissa (ξ) is $\frac{2}{3}$ L; $\frac{2}{3}$ representing the relative *vis viva* of the linear centre of oscillation ($\frac{2}{3}$), and L being Laplace's limit, or the locus of synchronous rotation and revolution.

δ. The initial ratio ($\eta \zeta^2 = 1.66768$) differs by less than $\frac{1}{10}$ of one per cent. from $\frac{5}{3}$; $\frac{5}{3}$ being the ratio of rupturing *vis viva* to residual *vis viva* of rotation ($1 - .4 = .6$).

ε. The planetary field is geometrically intermediate between the fields of solar nucleation and of stellar projection. There are 9 abscissas be-

tween Sun's surface and $\frac{1}{2}$ Mercury ; 9 at loci of theoretical planetary rupture ; 9 between $\frac{7}{6}$ Neptune and the region of the fixed stars.

ζ. The 27th abscissa from Sun's surface, or the 19th from ξ, $(\xi\eta^{19}\zeta^{361})$, is L M $\div$ r_0 ; M being the elastic modulus of light at Sun's surface. (L = 36.36 r_0 ; M = 474600 r_0.)

η. The 28th abscissa from Sun's surface, $(\xi\eta^{20}\zeta^{400})$, is 46352440. Four recent estimates of the distance of α *Centauri* range between 45340000 and 48479500. Searle* cites authorities ranging between 44252 00 and 49169000. Newcomb says,† "The mean of all the measures of the parallax of this pair of stars hitherto made, gives 0''.93 as their most probable parallax, corresponding to a distance of 221000 astronomical units." This is equivalent to 47463340 r_0.

It will be readily seen that the elements of the paraboloid, ($\frac{1}{6}$ r_0, L, M), are entirely independent of any observed or theoretical planetary distance. No values can be assumed for those elements, within the limits of possible uncertainty, which will weaken the evidence that the nebula-rupturing position of the several planets, the time of solar rotation, and the interstellar spaces, have been determined by the laws which govern luminous undulation.

VI. Cosmical Determination of Joule's Equivalent.

In estimating heat of dissociation, Pfaundler has shown‡ that the mean should be taken between the temperatures of incipient and of complete dissociation. On this principle, in estimating the temperature of water-crystallization we should have regard to all stages of the expansion in molecular rearrangement, and take the mean (35°.6 F. = 2°C) between the temperatures of greatest density (39°.2 F = 4°C) and of complete crystallization (32° F = 0°C). So long as water continues to condense, its tendencies are centripetal and polar ; while it is expanding, they are centrifugal and equatorial. The thermodynamic relations between heat and work should be shown in the comparative motions and temperatures of polar and equatorial waters, as surely, and with as abundant facilities for accurate measurement, as in the experiments of the laboratory or in the processes of the workshop.

Johnston's Physical Atlas gives 82°.6 F (28°.1C) as the mean temperature of the oceanic warmth-equator. This indicates a polar-equatorial difference of 82°.6 — 35°.6 F = 47 J, or 28°.1 — 2°C = 26.1 calories. The difference in gravitating measure can be readily deduced from the differences of motion. The velocity of equatorial rotation is 1525.78 feet, which represents a fall of $\left(\frac{1525.78}{32.088}\right)^2 \times 16.044$ ft. = 47 J. Hence we find J = 771.816 foot-pounds ; Calorie = 423.44 kilogrammetres.

* Outlines of Astronomy, p. 396.

† Popular Astronomy, p. 208, foot note.

‡ Pogg. Ann., 1867, 131, 603.

The modulus (λ) of the velocity of rotation (v_r) is: $\lambda = \frac{v_r^2}{g} = \left(\frac{t_1}{t_0}\right)^2 r.$

Substituting the values of v_r, g, t_1, t_0, we find $\lambda = \frac{1525.78^2}{32.088} = \left(\frac{5074}{86164}\right)^2 r$ $= 13.741$ miles $= \frac{1}{288.4} r$.

This gives 3949.084 miles for the polar radius, which is $\frac{1}{3}$ mile less than Bessel's estimate, and about $\frac{3}{10}$ of a mile less than Clarke's estimate from the results of the British Ordinance Survey. It accords very closely, however, as we might reasonably have anticipated, with the ellipticity $\left(\frac{1}{288.0}\right)$ as deduced from pendulum experiments.*

Relations of Chemical Affinity to Luminous and Cosmical Energies. By *Pliny Earle Chase, LL.D.*

(Read before the American Philosophical Society, April 16, 1880.)

All the principles which I have applied successfully to the discovery of harmonic relations of cosmical mass and density, should be applicable also to the discovery of similar relations of molecular mass and density, and to a consequent extension of our knowledge of chemical physics. The application can be made most properly by chemical experts, but some indications of the methods to be pursued may be acceptable, even though they come from one who makes no claim to any special chemical experience.

In 1833, Sir John Herschel published his remarkable attribution to the energy of the Sun's rays, "of almost every motion which takes place on the surface of the Earth. By its heat are produced all winds, and those disturbances in the electric equilibrium of the atmosphere which give rise to the phenomena of lightning, and probably also to those of terrestrial magnetism and the aurora."†

In 1856, Kohlrausch found that the ratio between the electrostatic and the electromagnetic units was apparently, and perhaps exactly, equivalent to the velocity of light‡ (v_λ).

In 1863, I found that the reaction of gravity to the elasticity and *vis viva* of atmospheric rotation, furnished a simple method for approximately estimating the Sun's distance by means of barometric fluctuations,§ and began a series of studies of cosmical and molecular harmonies which are dependent and consequent upon general kinetic laws.

In the year following,‖ I announced "the discovery of certain new relations between the solar and lunar diurnal variations of magnetic force

* Enc. Brit., 9th edition, vii, 601.

† Outlines of Astronomy, § 399.

‡ Pogg. Ann.

§ Proc. Am. Phil. Soc., ix, 287.

‖ Ib. ix, 425.

and of barometric pressure," showing a numerical equivalence between tidal attractions and magnetic disturbances. In 1873, in his "Electricity and Magnetism" (vol. ii, p. 127), Maxwell suggested the tidal hypothesis, apparently without knowing that I had already adopted it and adduced evidence to sustain it.

In 1875, I showed that analogues of Ohm's law are operative in General Physics, Electricity, Chemistry, and Cosmogony, and that Maxwell's deductions, when combined with my theoretical assumptions, led to the ratio: Earth's mass : Sun's mass : : 1 : 327710.*

Prof. Robert B. Warder has lately called my attention to the fact that the co-efficients of elasticity seem to lend some confirmation to Mendelejeff's and Meyer's hypotheses of periodical chemical functions, and thus I have been induced to look for further chemical illustrations of the universal influence of luminous undulations.

In the general equation of absolute measure, $u = F(l, m, t)$, u, l, m and t represent, respectively, units of velocity, length, mass and time.

In Mechanical measure, the dimensions of the unit of force (k), which, in unit of time, communicates unit of velocity to unit mass, are $l\, m\, t^{-2}$.

In Electrostatic measure, the unit of quantity (ε), which repels an equal quantity at unit distance with unit force, is $l^{\frac{3}{2}}\, m^{\frac{1}{2}}\, t^{-1}$.

In Magnetic measure, the unit of quantity (μ), or strength of unit pole, is also, $l^{\frac{3}{2}}\, m^{\frac{1}{2}}\, t^{-1}$.

Kohlrausch's equation, $u = l\, t^{-1} = v_{\lambda}$, has been subsequently investigated by Weber, Thomson, Maxwell, and Perry and Ayrton, each successive examination increasing the probability that the electric dimensional value of $l\, t^{-1}$ is precisely equivalent to the velocity of light.

If we adopt for our mechanical unit, the maximum energy of gravitation in the solar system, we get the following equation:

$$g = l\, m\, t^{-2} = m\, u\, t^{-1} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{A}$$

The units of Electrostatic and Magnetic measure, both give the equation:

$$l^{\frac{3}{2}}\, m^{\frac{1}{2}}\, t^{-1} = mu.\, m^{\frac{1}{2}}\, l^{\frac{1}{2}} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{B}$$

From these dimensional equations the value of the unit of absolute momentum (mu), is readily deduced. If we multiply (A) by the identical equation $t = t$, and (B) by the equation of orbital velocity ($v = m^{\frac{1}{2}}\, l^{-\frac{1}{2}}$†), we get

$$g t = mu = mv_{\lambda} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{C}$$

$$\varepsilon v = mu = mv_{\lambda} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{D}$$

$$\mu v = mu = mv_{\lambda} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{E}$$

Under the guidance of foregoing investigations I find the following interpretation for this equivalence.

The centre of gravity of the solar system has a locus of secular range

* Ib. xiv, 607—9.

† Substituting r for l, the equations $g = \frac{m}{r^2}$ and $v = \sqrt{gr}$, give $v = m^{\frac{1}{2}}\, r^{-\frac{1}{2}}$.

relatively to Sun's centre, nearly, and perhaps exactly, equivalent to Sun's diameter.*

The two controlling bodies of the system, Sun and Jupiter, are of nearly equal density, and their centre of gravity, which is also the centre of greatest relative stability, has a locus of relative secular range about equivalent to $\frac{1}{2}$ of Sun's diameter, its secular perihelion, or locus of primitive rupture, being at Sun's surface. The gravitating motions beyond the limits of the system, and the ethereal motions at all points, should be referred to the centre of greatest stability; but as we approach that centre the gravitating tendencies towards Sun's centre become more and more preponderating. The gravitating motions are greatest at Sun's surface, where solar gravity (g_0), is 27.83 times as great as terrestrial superficial equatorial gravity (g_1). In solar rotation, the particles are subject to continual ethereal and gravitating forces, referable to the centre of stability and to Sun's centre, respectively.

Projectile velocities at Earth's surface, may be represented either by gt or by $\sqrt{gh}$, t being $\frac{1}{2}$ the time of flight and h being twice the virtual rise or fall. Reasoning from analogy we may, therefore, presume that t, in equations A, B and C, represents $\frac{1}{2}$ solar rotation, l represents the height of a homogeneous ethereal atmosphere, at Sun's surface, which would have a wave-velocity equivalent to that of light, and m represents a *minimum mobile*, or constituent molecule. These conditions are all satisfied by the values, solar rotation $=$ 25.486 dys; $t = 12.743$ dys. $=$ 1100985 sec.; $v_\lambda = 688.815 \sqrt{gr}$; $l =$ modulus of light $= (688.815)^2\, r = 2306.5$ Earth's semi-axis major $=$ 73.64 Neptune's semi-axis major.

An ethereal sphere, rotating with velocity $\sqrt{gr}$ at Sun's surface, would have v_λ at 688.815 r. If $mu = v_\lambda$ in both cases, the densities would be inversely as the distances. In a condensing or expanding nebula, the nucleal radius varies as the $\frac{2}{3}$ power of the atmospheric or Laplace-limiting radius, and in an elastic atmosphere the density varies geometrically, with an exponent inverse to the arithmetical variation of the distances or to the square of arithmetical variation or *vis viva* of rotation. Sun's mean distance is 23395.4 terrestrial radii, and 23395.4 r $\div$ $(\frac{2}{3})^2$ of 688.815 $=$ 60.88 r, which is the value of Moon's semi-axis major, as found by the limiting time-ratio of terrestrial rotation to satellite revolution.†

The tendency of all movements in elastic media, either to complete or to harmonic synchronism, should introduce some simple relations of chemical *vis viva* to *vis viva* of terrestrial motion. The law of Dulong and Petit, with Clausius's modifying substitution of the square of the molecular velocity for the specific heat, may be expressed by the equation $\frac{wv^2}{t} = C$, in which w represents the atomic weight, v the molecular velocity, according to the kinetic theory of gases, and t the absolute temperature. Since

* From *a priori* considerations I am inclined to think that the accordance is exact.

† Proc. Am. Phil. Soc., xix, 9.

the terrestrial movements are either independent of the absolute temperature, or standing in unknown relations to it, the simplest evidence of equivalent *vis viva* should be sought at some specific temperature, and in the most typical and most widely diffused gases. We have already seen that the universal typical liquid, H_2O, furnishes data for a ready determination of Joule's equivalent, at the mean temperature of solidification ($2°C = 35°.6$ F); let us examine the constituent typical gases (H, O) at the same temperature.

According to Clausius,* the mean velocities of the molecules are:

	At 0°C.	At 2°C.
Oxygen,	$461\ m = 1514$ ft.	$464.4\ m = 1525.1$ ft.
Hydrogen,	$1844\ m = 6050$ ft.	$1857.5\ m = 6094.3$ ft.

Earth's equatorial velocity of rotation (1525.78 ft.) accords with the molecular velocity of oxygen; its velocity of revolution is 16 times the velocity of hydrogen. If w_n represents the atomic weight of any perfect gas n, the velocity at 2°C may be found by the equation:

$$v_n = \frac{4v_r}{\sqrt{w_n}} = \frac{1}{16}\sqrt{\frac{gr}{w_n}}$$

The mean molecular velocity of oxygen and hydrogen (3048.7), is to Earth's orbital velocity, as the square of the time of fall to the centre from any distance d, is to the square of the time of orbital revolution at d.

The following comparison with the results of Cornu's and Michelson's experimental determinations of the velocity of light, and with my own estimation of Sun's mass and distance from the explosive energy of H_2O,† will show the closeness of agreement between the chemical and other physical approximations.

	Sun's Distance.	Velocity of Light.
Chase, H_2O	92,639,500 miles,	186,090 miles = 299,470 km.
Michelson,	92,748,000 "	186,300 " = 299,820 "
Chase, H	92,756,000 "	186,320 " = 299,850 "
" HO	92,803,000 "	186,420 " = 300,000 "
" O	92,849,000 "	186,510 " = 300,150 "
Cornu,	92,803,000 "	186,420 " = 300,000 "

It may be interesting, in this connection, to give two additional illustrations of the tendency to harmonic wave lengths in elementary spectra, of which I have already presented many evidences.‡

If we take $n = \frac{1}{285}$, we find that Vogel's wave-lengths,§ of the ultra-violet lines in the spectrum of hydrogen, are strictly harmonic, as will be

* Phil. Mag., 1857, xiv, 124.

† Proc. Am. Phil. Soc., 1872, xii, 394.

‡ Proc. Am. Phil. Soc., xvii, 109–12, 295–301; xviii, 224-6.

§ Photographic News, February 20, 1880.

seen by the following table. Column T contains theoretical harmonic wave-lengths; V contains Vogel's measurements:

		T	V
α	$3968.4 \div 1$	$= 3968.4$	3968
β	$3968.4 \div (1 + 6\,n)$	$= 3886.6$	3887
γ	$3968.4 \div (1 + 10\,n)$	$= 3833.9$	3834
δ	$3968.4 \div (1 + 13\,n)$	$= 3795.3$	3795
ε	$3968.4 \div (1 + 15\,n)$	$= 3770.$	3770

The divisors ($\beta = 1 + 6\,n$; $\gamma = 1 + 10\,n$; etc.) give the following proportions:

$\beta-\alpha : \varepsilon-\alpha$: : mean e.e. of rotation : Equatorial e.e. of rotation.

$\varepsilon-\gamma : \varepsilon-\beta$: : wave e.e. : molecular e.e.

$\varepsilon-\delta : \varepsilon-\gamma : : \beta-\alpha : \varepsilon-\alpha$.

If we take $n = \frac{1}{12}$, Paalzow's oxygen lines* (P) are also nearly harmonic (T_1).

	T_1	T_2	P
$602 \div 1$	$= 602.$	602.	602.
$602 \div (1 + n)$	$= 555.7$	558.2	558.2
$602 \div (1 + 2\,n)$	$= 516.$	519.2	519.
$602 \div (1 + 3\,n)$	$= 481.6$	481.1	481.
$602 \div (1 + 4\,n)$	$= 451.5$	452.3	453.

The numbers in column T_2 are also harmonic, if we take $n = \frac{1}{33}$.

Stated Meeting, May 7, 1880.

Present, 15 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Mr. Ellis Yarnall, dated 105 S. Front Street, Philadelphia, April 21, 1880; Dr. Austin Flint, Jr., New York City, 14 West 33d Street, April 21; Mr. Joseph C. Fraley, 1833 Pine Street, Philadelphia, April 22; Mr. Horace Howard Furness, 222 West Washington Square, Philadelphia, April 24; Rev. George Dana Boardman, 3815 Walnut Street, West Philadelphia, April 26; Mr. J. Vaughan Merrick, Philadelphia, April 27; Mr. Wm. B. Rogers, Jr., 1000 Walnut Street, Philadelphia, April 27, and Mr. C. P. Patterson,

* Monatsber. der K. Akad. zu Berlin, Sept., Oct., 1878.

U. S. Coast and Geodetic Survey Office, Washington, D. C., April 21.

Letters of acknowledgment were received from L. Rütemeyer, Basel, May 20, 1880 (100,103); Society of Antiquaries, London, April 23, 1880 (103, 104); R. Astronomical Society, London, April 15, 1880 (103, 104); Victoria Institute, London, April 10, 1880 (103, 104); Royal Society of Edinburgh, Sep. 1879 (102); New Hampshire Historical Society, Concord, May 3, 1880 (105); Essex Institute, Salem, May 3 (105); New York Historical Society (105); New Jersey Historical Society, Newark, May 3 (105); Numismatic and Antiquarian Society of Philadelphia, May 3 (105), and Mr. Henry Phillips, Jr., Philadelphia, April 29 (105).

Also, Postals acknowledging the receipt of Proceedings No. 105 were received from the Museum of Comparative Zoölogy, Cambridge; Mr. Alex. Agassiz, Cambridge; Yale College Library, New Haven; the Astor Library, and American Ethnological Society, New York; Prof. J. J. Stevenson, New York; Historical Society, Philadelphia; Dr. T. Green, Easton; Mr. Wm. B. Taylor, Washington; Dr. Robert Peter, Lexington, Ky.; University of Cincinnati, Ohio, and the State Historical Society of Wisconsin, Madison.

Letters of Envoy were received from Dr. Geo. Engelmann, dated St. Louis, April 24, 1880, and the Department of the Interior, Washington, April 29, 1880.

A letter requesting some numbers of the Proceedings was received from the "Verein für Erdkunde" of Dresden, and was referred to the Secretaries with power to act.

Donations for the Library were received from the Governor General of India; Editor of the Zoologische Anzeiger, Leipsig; Dr. Hugo Von Meltzel; R. Accademia dei Lincei, Rome; Editor of the Revue Politique, Paris; Société de Géographie Commerciale, Bordeaux; Real Academia de la Historia, Madrid; Royal Astronomical Society, and Editors of Nature, London; Royal Society of Edinburgh; Essex

Institute, Salem, Mass.; Boston Society of Natural History; Museum of Comparative Zoology, Cambridge; American Antiquarian Society, Worcester; American Journal, New Haven; American Chemical Society, N. Y.; Historical Society, Numismatic and Antiquarian Society, Franklin Institute, American Pharmaceutical Association, Editors of the Medical News, and Journal of Pharmacy, and Mr. Henry Phillips, Jr., Philadelphia; Dr. Albert S. Gatschet, Washington; Johns Hopkins University, and Editors of the Journal of Mathematics, Baltimore; Department of the Interior, Washington; University of Virginia; Editor of the American Antiquarian, Chicago; Dr. Geo. Engelmann, St. Louis, and the Ministerio de Fomento, Mexico.

Mr. Moncure Robinson read a biographical memoir of the late Michel Chevalier.

Mr. Henry Phillips, Jr., presented for the Proceedings a paper by Prof. E. D. Cope, entitled, "Second Contribution to the History of the Vertebrata of the Permian Formation of Texas."

Pending new nominations Nos. 904 and 909 to 916 were read.

The Committee on the Michaux Legacy reported that the portrait of F. A. Michaux had been copied, and that it was now in the room for the inspection of the members.

Mr. Fraley reported the receipt of the last quarterly interest on the Michaux Legacy, amounting to $132.42.

The President suggested the desirability of the Society's now placing on its walls a portrait of Dr. Wood, deceased, the late President of the Society.

On motion of Mr. J. S. Price it was resolved, that a copy should be made for the Society, under the charge of the Hall Committee and the Curators.

The President reported that he had selected a delegation from the Society to represent it at the approaching Centennial of the American Academy of Arts and Sciences in Boston, and that six of those so appointed had signified their acceptance and would act in that capacity.

And the meeting was adjourned.

Obituary notice of Michel Chevalier. By Moncure Robinson.

(*Read before the American Philosophical Society*, May 7, 1880.)

I come before the Society for the first time for many years, in discharge of a duty devolved on me by you, the discharge of which revives in me many recollections both pleasant and painful. The eminent political economist and statesman of whom you have requested me to prepare an obituary notice, was not only a member of our Society, but one of my oldest and most attached friends, one whom I have known intimately for nearly half a century, and for whom my affection and admiration steadily increased, from the period of our first acquaintance, to the day of his death. It is not remarkable that it should have been so, for Mr. Chevalier was a man of heart, as well as head, whose whole life was devoted to the service of his country and his fellow men, and one who, whilst undemonstrative and apparently cold on a first acquaintance, was unusually benevolent and kind in his nature, and capable of the warmest attachments for those whom he thought possessors of, and appreciative of, such qualities.

You will be curious to know something of the early youth of such a man, and it is a gratification to me, to be able to give it to you, in some detail.

Mr. Chevalier was born at Limoges, *chef-lieu* of the department of the Haute Vienne, the 13th of January, 1806. He was the eldest son of Jean Baptiste Chevalier and of Marie Gurand, both natives of Limoges. They had four other sons, Auguste, Emile, Martial and Gustave, of whom the first three made their names known, both in their native country, and other lands ; the first as Secretary General of the Presidency, in the days of the second Republic of France, from November, 1849 to 1852 ; the second as a highly educated and accomplished military and civil engineer, known to many of the citizens of Philadelphia more than forty years ago, when he commenced the practice of his profession as an assistant engineer, on the Philadelphia and Reading Railroad, then under construction, and who has since continued this career both in Europe and America, and been occasionally occupied in missions of his government in England, and on the Isthmus of Panama ; the third, Mr. Martial Chevalier of the French Consular Department, who was for several years (within the last ten) the Consul General of France, at Quebec, and afterwards at Havana. I had not the advantage of a personal acquaintance with the father of these gentlemen, who at the time that his distinguished son, Mr. Michel Chevalier was making the name an honored one throughout the world, was only a small *commerçant* at Limoges, and confined there constantly by his occupations ; but I had the pleasure, during a visit to France in 1837, of seeing often the mother of Mr. Michel Chevalier, and his devoted sister Pauline (afterwards Madame Moroche), and I then learned the secret of his rapid rise in public estimation as a writer and statesman. But I am proceeding too rapidly, and must go back a little, and redeem my promise to tell you something of an earlier period.

The boy Michel Chevalier entered as a boarding pupil the College of

Limoges, at the age of eleven, and made the most brilliant progress in his studies. He bore off nearly all the prizes in his classes, from the day of his entrance in this institution. He was equally distinguished in both the literary and scientific classes, but most remarked on, for his attainments in mathematical science. His taste and aptitude for the last, enabled him to undergo earlier than usual, the examination for the Polytechnic School at Paris, which he entered in the month of November, 1823, at the age of 17, one of the first in the list of candidates for admission of that year. At the end of 1825, he left the Polytechnic School, equally remarkable for his attainments in it, as at the Lycée of Limoges, to enter as *Elève Ingénieur* in the School of Mines. In 1829, he obtained his degree of Engineer of Mines, and was sent as Resident Engineer to the important department of Valenciennes.

Had the ambition of Mr. Chevalier been only professional, he would, with this starting point, have probably been like his distinguished contemporary, Mr. Le Play (the Commissioner-in-Chief of the Great Paris Exposition of 1867), at an early age, one of the eminent members of the profession of Mining engineers in Europe; but his reading and researches both in the Polytechnic School and School of Mines, in Paris, had gone far beyond the curriculum of studies in those institutions, comprehensive as that was, and including as it did every thing pertaining to the subjects taught in them. The quick intellect and remarkable memory of Mr. Chevalier enabled him, during the six years of study at these grand institutions, the chairs of which were then filled by world-renowned names, to spare time for outside reading and research, as well as the preservation of the early classical lore and polite learning imbibed by him at the Lyceum of Limoges; and his tastes were for everything useful and ornamental to our race, but especially for the useful, and what would add to the comforts of and elevate the masses.

The revolution which dethroned Charles X. and made Louis Philippe King of the French, which, in the language of General Lafayette, "made France a Monarchy with republican institutions," took place in the following year (1830). Many now living among us must recollect the excitement throughout the civilized world, which followed this change. It was naturally excessive in France, and it is not remarkable that at such a time minds of the highest order with corresponding aspirations, were most profoundly agitated. Mr. Chevalier in his various reading had been attracted by the writings and doctrines of St. Simon, in which at the commencement there was much to attract, as well as to find fault with. There was nothing like communism in them, but the reverse. The leading maxim of St. Simon was, "*To every one according to capacity, and to every capacity according to its works,*" and it is not surprising with such a motto on its banner, that St. Simonism should have found among its votaries, young minds of the highest ability and culture, and especially those who, like Mr. Chevalier, believed that the advancement of France in wealth and prosperity, would be greatly and rapidly promoted by improved lines of communication, especially by a well-arranged system of railroads, and more freedom of trade than existed previous to the revolution of 1830.

So it was, that Mr. Chevalier and other distinguished pupils of the Polytechnic School, and the Schools of Bridges and Highways, and Mines, became in 1830 St. Simonians, and he one of the leaders of the sect and editor of the *Globe*, its organ, until its suppression by the government in 1832, when Mr. Michel Chevalier as its *Reducteur-en-Chef*, was condemned to imprisonment for a year, from which he was released at the expiration of six months, and immediately appointed by Mr. Thiers, then Minister of Public Works (who had not forgotten in the St. Simonian, the young and talented Engineer of Mines of the Department of the North), to visit the United States, to inquire minutely as to its canals and railroads, and the financial and banking systems, both of the States and the General Government.

In this mission, including a visit of a few months to Mexico, Mr. Chevalier occupied about two years in 1833, '34 and '35; and during his travels in the United States, he addressed to the *Journal Des Debats*, from different points on his route, frequent letters, beautifully written, exhibiting large reflection, both on the subjects of his mission, and others of equal interest, and indicating with great tact many industrial hindrances in his native country, which he considered burdensome. These letters, with some slight changes, were published in 1836, in two octavo volumes, and gained him immediately the spontaneous plaudits of eminent men of both continents, and a high reputation among the writers and thinkers of Europe. Mr. Gallatin said of them that they were the most graphic and truest view of the social condition of the United States; and the great Humboldt wrote to him that his book might be considered a treatise on the civilization of the people of the West. He was indebted to this work for an appointment by the French government on a mission to England, in 1837, to study there, the causes and effects of the commercial crisis, which commencing in the United States at the close of 1836 had extended to England in 1837. This mission proved an unfortunate one for him. A few days after his arrival in London, in returning from a session of Parliament with Mr. Bourqueney, the then Chargé d'Affaires of France to England, in the carriage of the latter, the horses ran away and upset the carriage. Mr. Bourqueney was but slightly injured by the accident, but Mr. Chevalier having fallen on his head, was taken at once to the house of the French Minister, was for several days insensible, and his life for some weeks in serious peril; and it was only after passing several months in the south of France, and at the Pyrenean Baths, that his health was sufficiently re-established to admit of his resuming his labors.

At the expiration of a year from his recovery, near the close of 1838, he published his celebrated work, entitled "*The Material Interests of France, its Roads, Canals, and Railroads.*" This work was, to a great extent, a programme of ameliorations, many of them suggested by him, soon to take place, and which made the France of 1850 scarcely recognizable by travelers who had known well the France of 1840.

Such had been the brilliant and useful career, and such was the position

of Mr. Chevalier in the winter of 1838–39, when he was scarcely thirty-three years of age. Honors and distinctions were then bestowed on him rapidly. Appointed "Master of Requests" in 1836, he became successively Counsellor of State, member of the Superior Council of Commerce, Chief Engineer of Mines, and in 1841, at the age of 35, successor of the celebrated Rossi, as Professor of Political Economy in the College of France. No appointment could have been more gratifying to Mr. Chevalier than this. His lectures were to be on subjects familiar to him, to which his thoughts had been given from the time of his entrance in the Polytechnic School, and it was a labor of love to him to prepare and deliver them. Though the recipient since of many distinctions and honors, among them that of Senator of France in 1860, and charged with corresponding duties, and obliged occasionally to devolve on a substitute his duties as professor, he continued to hold the Professorship of Political Economy, in the College of France until his death, with the exception of a brief period after the Revolution of 1848, when he was deprived of his chair by the Provisional government of the day, but which was restored to him in the course of a few months by a vote of the National Assembly.

Mr. Chevalier, though eminent as a Political Economist and Publicist, and zealous always in promoting what he believed to be the interests of his country, was in no sense a party man. He was an admirer of Mr. Thiers, and an attached friend of Count Molé, successive Ministers of Louis Philippe, but he had no difficulty in opposing important measures recommended by them as Ministers, of which he did not approve; and he manifested signally in 1870 his independence when he stood in the Senate Chamber almost, if not altogether alone, in voting against the Prussian War. When in France in 1867, on hearing his name mentioned as a man of pre-eminent ability by a gentleman of influence in the Orleanist Party, and bearing one of the renowned names of France, I was tempted to ask how it came to pass that Mr. Chevalier had not been in the Cabinet of either Louis Philippe or Louis Napoleon. His reply was simply "*Il traverse trop son chemin*," showing that in Empires and Monarchies, as in the United States, those who would be cabinet officers and dispensers of government patronage, must give up to a greater or less extent their independence of opinion, which conscientious and really able men cannot readily surrender.

Mr. Chevalier was elected in 1845 a Deputy of the Department of the Aveyron, and during the same year was married to Mlle. Emma Fournier, a highly educated and accomplished young lady, the only daughter of a large and wealthy manufacturer of Lodève in the Department of the Herault; and in 1851 he was elected a member of the Institute of France, in the Department of Moral and Political Sciences.

He had thus attained at the age of 45, all that, if a selfish or merely ambitious man, he could have desired. With an ample income from the honorable positions held by him, and occasional contributions of his well-considered views, on subjects of public interest, to the regular periodicals and

daily press of Paris, and his excellent wife (as the future proved her to be) the almost certain inheritor of a large estate, there was every temptation to him, laboring as he did under the disadvantage of a very delicate constitution, to spare himself in the future; but his mind and heart were of that order which considers nothing done whilst anything remains to be done, for his country and humanity; and he regarded the advantages attained by him in the prime of life, only as stepping stones to increased usefulness.

In 1852, as Counsellor of State, Mr. Chevalier was placed in the section of Public Works.

In 1855, he acted as President of the French section of the World's Exposition of that year in Paris; and for the ten years between 1860, in which year, as above observed, he was made Senator, to 1870, when the Empire ceased to exist, he took an important part in all discussions, in and out of the Senate, pertaining to financial and industrial questions. The most signal and important service rendered by him to his country during this period, was the commercial treaty of 1860 between France and England. Of this treaty, his son-in-law, Mr. Paul Leroy Beaulieu, a member of the Institute, and the distinguished *Rédacteur-en-Chef* of the *Economiste Français*, in the number of that Journal of the 6th of December last, says:

"The conception of the treaty of 1860 was due entirely to Mr. Michel "Chevalier. It was he who of his own sole motion, without any official mis-"sion, went to England to see Cobden and Bright, to propose to them an "arrangement in this way. Cobden had at first some hesitations. A treaty "of commerce appeared to him a *compromise*, contrary to true economical "doctrines. Mr. Michel Chevalier converted him, and then addressed "himself to Mr. Gladstone. Assured of the coöperation of the English "Government, Mr. Chevalier then returned to France, explained his "views to the Emperor, and obtained his support of them. Several of the "Ministers of that date were nevertheless opposed to a step so decisive in "the way of commercial liberty, but Mr. Rouher comprehended the great "usefulness and productiveness of the projected treaty of Mr. Chevalier. "Thus this great work, the treaty of 1860, which marks a new evolution "in the economical relations of nations, was in its principles, as well as its "initiation, a private one due to the inspiration of Michel Chevalier and the "adhesion of Richard Cobden. Nearly twenty years have passed upon the "treaty of 1860, twenty years which will be counted as among the most "agitated of History. The War of Secession of the United States, the "War of 1866, the French and German War, have disturbed the conditions "of the experiment of commercial liberty. Nevertheless, in spite of all these "disturbing elements, all the losses of capital, and all the uncertainties "which have during this period been the consequence of these great in-"ternational conflicts, the reform of 1860 has proved to be a beneficent "one; it has been so to such an extent, that though this treaty has been "denounced for nearly ten years, nothing has yet been found to substitute "it. It has been prorogued from year to year without the power, without

"daring to modify it. What might have been its results, had the experi-"ment been made in a period of peace, like that between 1815 and 1848?"

It was certainly due to this treaty which had been so effective during the previous ten years, in connection with her admirable system of railroads in developing her resources and increasing her wealth, that France was enabled to recover so rapidly from the results of the Prussian War, and to exhibit before the end of the next ten years, a picture of prosperity surpassed by that of no other country in Europe.

The above extract from the *Economiste Français* reminds me of a misapprehension in this country of the views of Mr. Chevalier on the subject of free trade, which I will avail myself of this opportunity to correct. The visit of Mr. Chevalier to the United States in 1833, had the effect of modifying very materially his views on many subjects. Previous to this visit, I think it not unlikely that the great, and in many cases, absurd, hindrances in France in the way of exchanges, both at home and with other countries, may have caused him to have entertained extreme free trade views; but Mr. Chevalier was a man of profound reflection, aiming at truth on that and every other subject to which his thoughts were directed, and eminently practical in his conclusions. After his return to France in 1835, the subject which first occupied his attention more than any other, was that of improved communications by *canals and railroads*, and it has been most fortunate for his country, that the programme of these given in his great work published in 1838, on "*The Material Interests of France*," was so closely followed. He abhorred the idea of allowing free competition to the extent admitted in England as well as in America in canals and railroads, believing the plan of giving an act of incorporation for either, to any association asking it, as not only permitting an unnecessary waste of the capital of the country, to an immense extent, and destructive of confidence in such investments, but as impairing the power of really valuable works to provide such accommodations for the public at fair rates, as they could otherwise afford, and as it would be to their interest to give, as well as the policy of the government to require. He believed, in short, in the right of eminent domain being used only in the case of improvements of decided value, and when used, in the rights of the public, being in all cases carefully guarded, and the accommodations of the improvement afforded at the lowest charges consistent with a fair remuneration to its owners; objects which could not be united under a system of free competition. As a consequence of the adoption of these views by his countrymen, there is no country in the world where so small a proportion of the capital invested within the last forty years in canals and railroads, has been wasted, or where traveling is safer, or in which travel and trade are accommodated, at more reasonable rates than in France.

It was impossible for one entertaining such views in regard to improved communications to be a *reckless* free-trader; and Mr. Chevalier, I have reason to believe, was on the subject of international commerce as conservative in his views, as he was in regard to railroads and canals. He believed

in the adoption of protective duties to a moderate extent for nascent industries, as in a patent-right or a copy-right for a limited time, for the protection of an author or inventor, and in the propriety of such duties as might be necessary to keep up a few industries essential to the defence of a country in time of war; but beyond this, he considered the protection given by a tariff based on revenue principles, all that was justifiable or judicious. Practical as he was in all things, I have little doubt that his preference for an arrangement *by a treaty* between England and France, instead of the action of the legislative bodies of the two countries, was founded on the idea that what was advisable in the way of protection for each country, might best be effected by treaty.

Mr. Chevalier's connection with governmental affairs ceased with the Empire in 1870, and he consecrated himself for some time afterwards, to his duties as Professor in the College of France, and as member of the Institute; but his taste for great and useful enterprises continued, and he devoted himself in 1875, with his accustomed zeal, to carrying out one of his engineering conceptions, that of a submarine railroad between Calais and Dover, as a means of binding together more closely France and England. He organized during this year a society for the purpose of making examinations in reference to the work, of which the Messrs. Rothschild Brothers, and the railroad companies of the North, were members. This Society, of which he was the initiator, and of which he continued until his death the President, obtained of the government a concession of the submarine railroad, and Mr. Chevalier entered on the examination of the bed of the Channel, and an ascertainment of the strata underneath, with that ardor and perseverance which were parts of his nature. He had communicated with me as an old friend and confrère, when he first conceived the idea of the work, as to its practicability, and sent me, from time to time, lithographed copies of the soundings, and statements as to the character of the chalk formations, found at various depths below the level of the sea, on the line of the tunnel on both sides of the Channel, which up to the time of his death, were highly favorable. But the events in the East, and the condition of things in England within the last three years, have prevented, so far, the work itself being entered on, and it may not for some time, or perhaps never, be executed; but if it should be, the name of Mr. Chevalier will be always connected with it, as its first projector and promoter.

This and other plans for the benefit of his country and the world, occupied, I might say, to the last moments of his life, the thoughts of Mr. Chevalier. I speak knowingly on the subject, having been a recipient during his last and fatal illness (after it had progressed to the point that he could write only in a recumbent posture), of eight letters in less than six weeks, in which the submarine tunnel, and other subjects of public concern, were referred to, and discussed by him. In one of them, he speaks of an experiment he is making on his estate in the South of France, of growing American grape vines for the purpose of engrafting French grape vines on American stocks, as a means of arresting the Phyloxera, at present so destructive to the great wine industry of France; and I find from

the obituary notice of Mr. Paul Leroy Beaulieu in the *Economiste Français*, from which I have made an extract on a previous page, that from his bed of suffering on the evening preceding the day of his death, he directed, as President, a letter to the submarine railroad association, so impossible it was for him to avoid thinking (or acting) on subjects which interested him !

The life and labors of Mr. Chevalier ended on the 28th of November last. He died the morning of that day, at his country residence, Mont Plaisir, near Lodêve, in his 74th year, which would have been reached on the 13th of January of the present year.

I venture to translate from a letter from his affectionate and lovely daughter, Madame Paul Leroy Beaulieu, written me on the 2d of December, four days later, the portion communicating the sad intelligence of his death. "When (says Madame Beaulieu) my father received your last letter, he was already confined to his bed, from which he was no more to rise. His ankle was being rapidly cured, but as the cure of the ankle progressed, there came on successively a rheum, derangement of the stomach, and afles in the mouth, all ills which under other circumstance would easily have been borne, but which were too much for a frame for some years enfeebled.

"My poor father died on the 28th of November, after four weeks of suffering, and an agony of twenty-six hours. He preserved his consciousness until within a few hours of his death.

"All the physicians whom we have consulted, concur in opinion that his health had been *used up* by his labors ; and, in spite of all the watchful care which surrounded him, especially that of my mother, who never left him night or day for more than two years, the Almighty has not allowed us to preserve him.

"I have thought, dear sir, that these details in regard to so old and sincere a friend, would be of interest to you, and for this reason I have written you.

"I wish also to say to you that all those whom my father has loved are dear to us, and that we will be happy to learn that the painful trials we are undergoing, have been spared to them."

Mr. Chevalier's life was in fact one of almost constant mental labor, from his childhood to his death. This was so much his normal condition, that even at his hospitable home, he appeared often *distrait* and silent when thinking over something said by a guest which struck him as worthy of consideration, but in regard to which he was not at the moment prepared to express his concurrence, or dissent. That he was not unobservant, was evident from his accurate and minute recollection of men and things. He had one of the most retentive memories I have ever known, and seldom, I think, forgot anything he had seen or read, worthy of thought or remembrance.

With such varied ability, and such a taste for, and power of, labor, few subjects worthy of it escaped his attention, or were left, if within his purview, untouched by his pen. In one respect he was exceptional, and

perhaps stood alone, among the writers of his epoch. This was his rare union of a mind eminently scientific, with a beautiful imagination. This combination of what are usually deemed opposite mental traits, is apparent frequently in his writings, but is perhaps most apparent in his letters on North America, and in a smaller work published in 1863, on "Ancient and Modern Mexico."

With so quick an intellect, so fine a memory, and love of and capacity for labor, a great deal was written by Mr. Chevalier during the last half century, besides the works mentioned in this memoir. Independently of his letters from America which first attracted attention to him as a writer, he published in 1840, a large work on the "Lines of Communication and Public Works of the United States," with an accompanying atlas (two volumes in quarto and the atlas in folio), which has never been translated in English, but which made the internal improvements of the United States, at that time, better and more accurately known to Europeans than they were to ourselves. His lectures at the College of France and other works on Political Economy, and his brochures on Gold and Currency, are well known to readers on those subjects. In addition, he gave to the world a magnificent introduction to the reports of the International Exposition of 1867, and was a co-laborer during the whole period in the principal periodical journals of France, as well as a contributor of able articles on subjects of the day to the *Journal Des Debats.*

On the 1st page of this memoir, I mentioned having had "the pleasure during a visit to France in 1837, of seeing the mother of Mr. Chevalier, and his devoted sister Pauline (afterwards Madame Moroche) and learned then the secret of his rapid rise in public estimation, both as a writer and statesman."

Mr. Chevalier and myself were in Paris, students of our respective professions, in the years 1825, 1826, and 1827, but did not meet there at that time. Our acquaintance commenced when he visited this country on his mission from Mr. Thiers in 1833. He then brought me a letter from one of our Paris cotemporaries, asking my assistance to him in his objects, which it gave me pleasure to render. The more I saw of him the more interesting I found him, and when he left America to return to France in 1835, we had become attached friends. When I afterwards visited Paris in 1837, he was one of the first persons to call on me, and I was made literally at home, whenever I could spare time to visit him, in his modest apartment. I forget the street, and number; but it was not far from mine, which was at the Hotel de Londres in the Place Vendome.

Instead of the *appartement de garçon* in which I had expected to find my friend, I found his remarkable mother, and his sister Pauline and young brother Martial, residing with him; the two first, to relieve him of the trouble of taking care of himself, and thereby leave him more time for his studies and labors, as well as to make his time more pleasant in the brief intervals he allowed himself for recreation; and the younger brother brought with them to have, under the guardianship of his mother and sister, the advantages of Paris training without its perils.

Cordially received as I always was by every member of this little household, I soon discovered in the gentle, affectionate and unpretending mother of the Chevaliers, a lady of remarkable mind and energy, whose ambition it was to make every sacrifice, and to do everything in her power to forward the honorable aspirations of her sons, and especially of Mr. Michel Chevalier the eldest.

I had a few months later, on the occasion of his dangerous accident at London, a proof of the devotion of his young sister Pauline. Mr. Chevalier and myself occupied at the time of its occurrence a common parlor with adjoining chambers at Long's Hotel. How the news of the accident reached Paris so soon, I have never known. Electric telegraphs had not been introduced to any extent, and the only roads which then existed between Paris and London were the French paved turnpikes and English McAdamized roads; but on the third or fourth night after its occurrence [a shorter time than a reply to my letter to the family announcing it could have been received by me], I was awakened at 4 A. M. by a loud knocking at the door of my chamber, which proved to be from Mlle Pauline and her brother Auguste, who on hearing of the accident, rushed to London as fast as the *Malle-poste* in France and post-horses in England could carry them, to nurse their brother Michel; and who, after hearing my account of it, went at once to the French Embassy, and remained there constantly with him, until he could be removed without hazard, to Paris.

One can scarcely imagine surroundings more favorable to high development in an elevated and affectionate nature, than were those of Mr. Chevalier in his modest Paris apartment, of which I have given a glimpse only, in the above paragraphs.

Before closing this obituary notice, I should say a few words of Mr. Chevalier in private life. I have never known more beautiful family relations than those which existed in his household. But the extract from the letter of Madame Leroy Beaulieu given in this, brief as it is, tells what these were, better than anything which I could say on the subject. Few persons, I think, knew or understood Mr. Chevalier better than myself, and I can truly say that his nature was a most kindly and affectionate one to everybody; but no one could surpass him in his willingness, however occupied, to aid and assist young men desiring his counsel and advice in the opening of their careers. On this subject, I recollect hearing his excellent mother-in-law, Madame Fournier, complain of his good-heartedness in being willing, notwithstanding his unremitting labors, to give his time and advice, as well as pecuniary aid, to any one asking his assistance or counsel; and through life he enjoyed the reputation of unusual benevolence. In the language of Mr. Paul Leroy Beaulieu, from whom I have several times quoted in this notice, he looked usually at the best side both in men and things. He believed in Providence, in the definitive triumph of the good and true. His mind thus anchored, manifested increased resources under exigencies, and he found himself preserved under the most difficult circumstances from all discouragement.

Second Contribution to the History of the Vertebrata of the Permian Formation of Texas. By E. D. Cope. *

(Read before the American Philosophical Society, May 7, 1880.)

Since my synopsis of this subject, published in May, 1878, the accession of much new material had enabled me to make a number of important additions to it. Notes which record some of these may be found in the American Naturalist for September and December, 1878, and for April and May, 1880. The substance of these is included in the present essay.

At the meeting of the National Academy of Sciences, held in New York, in November, 1878, I pointed out that the scapular arch in the *Pelycosauria*† consists of scapula, coracoid and epicoracoid, which form a continuum in the adult, in the same way as the three elements of the pelvis in the same group form an os innominatum. The tibiale and centrale of the tarsus unite to form an astragalus which has no movement on the tibia. The fibulare forms a calcaneum. The distal side of the astragalus presents two faces, one of which receives a large part of the proximal extremity of the cuboid.

The structure of the scapular and pelvic arches is identical with that already described by Owen as belonging to the *Anomodontia*. Several important characters distinguish this group from the *Pelycosauria*, but the two together form an order which I have thought must, for the present at least, be retained as distinct from the *Rhynchocephalia*. The characters of this order, with its two sub-orders, are as follows:

THEROMORPHA Cope. Scapular arch consisting at least of scapula, coracoid and epicoracoid, which are closely united. Pelvic arch consisting of the usual three elements, which are united throughout, closing the obturator foramen and acetabulum. Limbs with the phalanges as in the ambulatory types. Quadrate bone proximally united by suture with the adjacent elements. No quadratojugal arch.

Pelycosauria. Two or three sacral vertebræ; centra notochordal; intercentra usually present. Dentition full.

Anomodontia. Four or five sacral vertebræ; centra not notochordal; no intercentra. Dentition very imperfect or wanting.

The *Rhynchocephalia* have no distal ischio-pubic symphysis, and apparently no epicoracoid bone. They have an obturator foramen, and a quadratojugal arch.

The order *Theromorpha* approximates the *Mammalia* more closely than any other division of *Reptilia*. This approximation is seen in the scapular arch and humerus, which nearly resemble those of the *Monotremata*, especially *Echidna;* and in the pelvic arch, which Owen has shown in the sub-order *Anomodontia* to resemble that of the Mammals, and as I have

* Abstract read before the National Academy of Sciences, April 20, 1880.

† See Proceed. Amer. Philos. Soc., 1878, p. 511 and 528.

pointed out, especially that of *Echidna*. The tarsus is also more mammalian than in any other division of reptiles. In the genus *Dimetrodon* the coracoid is smaller than the epicoracoid, as in Monotremes. The pubis has the foramen for the internal femoral artery.

A not less remarkable characteristic of the *Pelycosauria*, as represented by *Clepsydrops* and *Dimetrodon*, is their resemblance to the *Batrachia* in some important respects. This is seen in the scapular and pelvic arches, which resemble very much those of the *Urodela*, and of such types as *Eryops*. The small coössified coracoid only differs from that of *Eryops* in having two deep sinuses of its free border. The general form of the pelvis is similar, but the ilium has a special and peculiar articular face for the sacral diapophysis, which is wanting in *Eryops*. In the inferior arches, the absence of obturator foramen, and general boat-like form, are the same in both; but in the *Pelycosauria* the symphysis is not so deep, and the walls less massive. But the resemblance of these arches to those of the *Batrachia* in question is greater than to those of any order of reptiles.

Another point of resemblance to the *Batrachia* is seen in the humerus. In my previous essay on the *Pelycosauria* above cited, I defined six types of humerus as occurring in the Texas Permian. Two of these were described as wanting the foramen,* while the others were stated to possess it; other differences between these types exist, but they were not mentioned. Since then Gaudry has added a third form to the former group, which he has ascribed to a reptile under the name of *Euchirosaurus*. I have detected this form in my Texas collections together with another, which has no condyles at either extremity. Thus eight forms of humerus are found in this formation.

That the type with the supracondylar foramen belongs to the *Pelycosauria* has been satisfactorily shown by its presence in the skeleton of *Clepsydrops natalis* and in *Cynodraco major*, where Owen first identified it. I find the type without this foramen frequently associated with the skeletons of *Eryops*, and other *Stegocephali*. There is no other element that can be regarded as the humerus of this type. It moreover has distinct points of resemblance to the humerus of existing *Batrachia*, parallel with similarity traceable in the femora of the extinct and recent genera. There is then every reason for believing that we have in the humerus of *Eryops* and its allies, an element which approaches closely in its characters to that of the *Pelycosauria*, and hence to that of the *Monotremata*.

There are some other peculiarities which constitute resemblances of the same kind. The tooth bearing elements of the roof of the mouth have batrachian character. Such is the densely packed body of teeth seen in *Dimetrodon;* and so are the teeth on the vomer in *Empedocles*. There is also a possible existence of epiphyses, judging from various specimens of humeri in my possession of both *Pelycosauria* and Stegocephalous forms.

In spite of these approximations, the *Pelycosauria* are distinctively rep-

* This word was misprinted "fossa" l. c. p. 529.

tilian in their single occipital condyle, ossification of the basicranial cartilage, and single vomer.

Thus the reptiles and batrachia of the Permian period resembled each other and the *Mammalia*, more closely than do the corresponding existing forms.

PELYCOSAURIA.

THEROPLEURA Cope.

Paleontological Bulletin No. 29, May, 1878, p. 519, Proceed. Amer. Philos. Soc., 1878, p. 519.

A more complete specimen of the *Theropleura uniformis* than any hitherto obtained gives the following generic characters.

The teeth are generally similar to those of *Clepsydrops* and *Dimetrodon*, having compressed crowns with fore and aft cutting edges. The incisors are distinguished by the presence of a diastema. Posteriorly to this the teeth increase in size, and then diminish; one tooth near the middle of the series is the largest, but does not in this species very much exceed the others. There is at least one large incisor tooth. The bones of the head are smooth, and not sculptured; a character distinguishing the genus from *Ectocynodon*. The symphysis of the mandible is short.

The neural arches of the vertebræ are all distinct from the centra. Intercentra are not present in any of the thirteen vertebræ preserved, but there was probably one below the centrum of the atlas. The ribs are two-headed, the capitular process extending downward to the anterior border of the centrum. The neural spines of some of the vertebræ are greatly elevated as in the species of *Clepsydrops* and *Dimetrodon*. The scapula is long; the ilium is similar to that of the genera named. A character which has not been detected in either of the genera named is the presence of dermal rods, which from their position adherent to the vertebræ, I suspect to be abdominal, and similar to those of the genus *Oëstocephalus*. This is a batrachian character. The neural spine of the axis is extended fore and aft. The odontoid is distinct and is of large size. It has lateral and inferior articular surfaces.

THEROPLEURA UNIFORMIS Cope.

Paleontological Bulletin No. 29, p. 519, 1878.

This species is about the size of one of the larger *Varanidæ*, and about equal to the *Clepsydrops natalis*. It is characterized by a long and acuminate head, with a large lateral nostril on each side, well forwards, and approaching near the border of the diastema. In the specimen the top of the head is crushed and the postorbital portion is wanting. Anterior to the large lateral tooth there are nine teeth; posterior to it there are eighteen. The anterior cutting edge of the crown does not extend so near the base as the posterior, and is best marked on the anterior teeth. In the crowns preserved the edges are not serrate.

Measurements.	M.
Length of alveolar edge of mandible	.120
" from diastema to canine tooth	.030
" of centrum of atlas	.010
" " " " axis	.018
" " contra of following five vertebræ	.071
" " ilium at acetabulum	.040

The lanciform shape of the skull with its consequent peculiarities distinguishes this species from the *Clepsydrops natalis*, and the *Dimetrodon incisivus*. The canine tooth is more posterior, the teeth more numerous, and the alveolar borders less curved than in either of those species. The diastema is less excavated, and the muzzle less obtuse.

THEROPLEURA OBTUSIDENS, sp. nov.

This species is represented by nearly all parts of the skeleton, including jaws of both sides with teeth, numerous vertebræ, and bones of the limbs. Many of these pieces are preserved in continuous masses, thus greatly aiding in the identification of parts.

Although the species is not larger than the *Theropleura retroversa*, the neural arches are coössified with the centrum.

The jaws are long and rather slender, and there is no such inequality in the sizes of the maxillary teeth as in the genera *Dimetrodon* and *Clepsydrops*; the canine being scarcely larger than the others. The crowns are elliptical in section at the base, with straight sides; the sections of the crowns are lenticular, and the apices are not very acute. The superficial coating is striate with fifteen or sixteen rather obtuse ridges. The cutting edges are not very acute, nor are they denticulate. The number of teeth in the dentary bone cannot be precisely stated, but is about twenty-one.

The mandibular articular face consists of two open parallel grooves, one shorter than the other, extending obliquely to the long axis of the jaw. The palatal dentigerous bone is quite different from that of *Dimetrodon*. Its inferior face instead of being narrow, is rhombic. The ascending process arises from one of the terminal angles of the rhomb, and the horizontal process continues from the opposite angle in line with the inferior surface. The borders of the rhomb next to the ascending process are dentigerous; the one bears a single series of four large teeth; and the adjacent angle and side bear numerous small teeth.

The vertebræ have the elongated neural spines of the allied genera, and they are simple. The centra have curved articular margins indicating the presence of intercentra, which are, however, not preserved. Traces of sutural articulation with the neural arch remain. Many of the centra are much compressed and have a narrow sharp median keel. In a few vertebræ, apparently from the posterior part of the column, an angular ridge extends posteriorly from the base of the diapophysis; this is apparent also on a caudal centrum. This point is characteristic of the *T. retroversa*, but I do not find the large capitular facet of that species in the *T. obtusidens*. The

lateral ridges of *T. triangulata* are situated low down on the centra. The diapophyses supporting the tubercular articulation are frequently elongate.

The scapular and pelvic bones are of the usual type. The humeri belong to form second of my Pal. Bull. No. 29. They have rather slender shafts, and much expanded extremities. The proximal articular surface is well defined. The supracondylar foramen and other points are as in the *Pelycosauria* generally. There were probably distal condyles, but this is not absolutely certain.

Measurements.

			M.
Length of mandibular series of teeth (nearly complete), on block			.110
Length of crown of mandibular tooth			.008
Anteroposterior diameter of mandibular tooth			.004
Diameters of articular extremities of a vertebra on the same block	vertical		.021
	transverse		.020
Length of another centrum on same block			.020
Diameters of humerus (separate)	of head	larger	.065
		smaller	.013
	of shaft		.017

The above description represents the parts which belong either certainly or very probably to one individual. Bones of a second and larger animal are mingled with these. The species to which they belong is uncertain, but they resemble very much those of the *Theropleura obtusidens*, and may belong to a larger individual of that species. A femur has the form already described under the head of *Clepsydrops natalis*. (Paleontological Bulletin, No. 29, p. 510.) Some phalanges belonging no doubt to one or the other of the two animals, are like those I have already ascribed to *Clepsydrops*. They are depressed, and are expanded at the articular extremities. The distal extremities expand the most abruptly, and their convex trochlear face is without groove or keel, and is more extended on the inferior than the superior surface.

DIMETRODON Cope.

Proceedings American Philosophical Society, 1878, p. 512.

The accession of a considerable amount of material representing this genus enables me to add important points to our knowledge of its osteology. The most noteworthy additions include the greater part of the skeletons of two individuals of *D. incisivus;* and vertebræ attached to the pelvis and femora of *D. gigas*. There are also vertebræ of several individuals of *D. cruciger*, and various parts of the skull of a species distinct from the *D. incisivus*.

In both specimens of *D. incisivus*, portions of the palatopterygoid arch are attached to the maxillary bone. One of these elements is an oval plate with a thickening of its inferior side, so as to bevel the long border farthest from the maxillary bone. The surface thus produced is thickly studded with small conical teeth irregularly disposed.

A second tooth-bearing element of the palate is adjacent to the last. It

is a massive plate, the ends of which are produced in opposite directions; the one into a massive shorter prominence; the other longer and plate-like. Between these prolongations, the inferior edge of the bone bears a single row of well developed teeth. The patch of small teeth first described, commences at the extremity from which the longest process rises on the opposite side of the series of large teeth. This Z-shaped bone is, from its massive character, generally preserved, and I was long familiar with it, before I could refer it to its position. In one specimen, a part of it bearing teeth, adheres to the upper jaw at the diastema.

The posterior part of the skull of one of the specimens above mentioned displays typical reptilian characters. The occipital condyle is not perforated, nor divided by sutures. The exoccipital bones project well backwards. The lateral walls of the brain-case are massive as far forward as the exit of the fifth pair of nerves; anterior to this point they were thin or wanting. The basisphenoid carries two parallel descending laminæ, which bound a deep median fissure, and then unite anteriorly. Posteriorly they abut on a descending process, which is followed by a lid-like element which is applied to a circular fossa with a raised border near the occipital condyle.

The articular face of the articular bone of the mandible consists of two parallel cotyli, divided by a ridge of articular surface. This part of the jaw is much depressed, as in *Eryops*. The large teeth of the lower jaw are at the anterior extremity.

The neural spine of the axis is flat and elongate antero-posteriorly. From this point the neural spines rise rapidly in elevation until on the dorsal region they are many times as long as the diameters of the centra. The latter are not very unequal in their proportions in different parts of the column. Those from the posterior regions are less compressed than the dorsals and cervicals. The dorsals are separated by intercentra below, which are small in the *D. incisivus*, and larger in the *D. gigas*. All the ribs are two-headed, commencing with the axis. All the cervical and dorsal vertebræ have diapophyses with tubercular facets. The head of the rib is prolonged downwards and forwards to the prominent border of the anterior articular face, against which it abuts, but so far as yet observed, without a corresponding facet. On the caudal vertebræ the two facets of the ribs are approximated and finally are not distinguished. They are here coössified with the centra.

The humerus accompanying one of the specimens of *D. incisivus*, is of the form No. 3, of my description of humeri in the Paleontological Bulletin No. 29, p. 528. The extremities are expanded and the shaft is without diagonal ridge; the supracondylar foramen is enclosed, and the condyles are robust. The pelvis of the *D. gigas* is in general like that of *Clepsydrops natalis* (l. c., p. 510). The elements are coössified, but the ischiopubic symphysis is not so deep as in the *Batrachia* of the same beds. The ilium is shortened above, and its direction is at right angles to the long axis of the inferior elements. The foramen of the internal femoral artery is distinct. The femur of the

same individual of *D. gigas* has no head, but a regular wide crescentic proximal articular surface. Below this on the posterior side is the large trochanteric fossa, which is bounded by lateral ridges, which are at first equal, but one soon exceeds the other in height, forming a trochanteric ridge a little above the middle of the shaft. The condyles are distinct from each other and are flattened below. One of them bears a robust longitudinal crest above, which makes it much larger than the other, and causes the groove that separates them above, to look outward, or to the side which supports the trochanter.

Three of the species may be distinguished as follows:

Vertebral centra much compressed, acute below; neural spines without proecsses...*D. incisivus.*

Vertebral centra less compressed, obtuse below; neural spines without processes; larger............... ....*D. gigas.*

Vertebral centra compressed, not acute below; neural spines with cross projections...*D. cruciger.*

DIMETRODON CRUCIGER Cope.

American Naturalist, 1878, p. 830.

This species is not uncommon in the Permian Formation of Texas. It is characterized by the enormous length of the neural spines of the lumbar vertebræ, which form the dorsal fin seen in other species of the genus. They are found in masses adhering together like sticks or branches of bushes. In this species the spine sends off, a short distance above the neural canal, a pair of opposite short branches, forming a cross. At various more elevated positions there are given off tuberosities which alternate with each other. They form on several consecutive spines oblique rows. The spines are broadly oval in section, the long axis antero-posterior, and have a shallow groove on both the anterior and posterior aspects. The centra are elongate as compared with their other diameters, and are much compressed between the articular extremities, leaving a strong inferior median obtuse rib. Articular faces ot zygapophyses oblique. Diapophyses short and robust, with large costal faces, and standing below the prezygapophyses.

Measurements.		M.
Diameter of centrum	antero-posterior	.043
	vertical at end	.028
	transverse at end	.030
Elevation of posterior zygapophyses above centrum		.025
" cruciform process " "		.058
Expanse of posterior zygapophyses		.034
" cruciform process		.048
Diameter of spine at base	antero-posterior	.030
	transverse	.020
" " .090 above base	antero-posterior	.016
	transverse	.016
Length of several pieces of neural spines		.140

DIADECTIDÆ.

I have obtained three skulls of the *Empedocles molaris*, a species of this family, which display the occiput, and two of them the basis of the cranial and facial regions. From them I derive the following characters.*

The relations of the quadrate and zygomatic arches are as in the *Theromorpha* generally. The pterygoids extend to the quadrates, and the vomer bears teeth. The brain-case extends to between the orbits, and its lateral walls are uninterrupted by fissures from this point to near the origin of the *os quadratum*. There is an enormous frontoparietal foramen. The mode of connection with the atlas is peculiar. There is a plane facet on each side of the *foramen magnum*, which then expands largely below them. The bone which bounds it inferiorly, presents on its posterior edge a median concavity. On each side of this, is a transverse cotylus, much like those of an atlas which are applied to the occipital condyles of the *Mammalia*. They occupy precisely the position of the Mammalian condyles. The median point of their upper border, which forms the floor of the foramen magnum, is produced in the position occupied by the median occipital condyle of a reptile. From its position between the cotyli, the section of this process is triangular. The element in which the cotyli are excavated has the form of the mammalian basioccipital, and of the reptilian sphenoid. It is not the batrachian parasphenoid. Its extreme external border on each side where it joins a crest descending from the exoccipital, is excavated by a circular fossa which looks outwards.

The character of this articulation is so distinct from anything yet known among vertebrated animals, that I felt justified in proposing (l. c., p. 304) a new division of the *Theromorpha* to include the *Diadectidæ*, to be called the *Cotylosauria*. The superior facets described, indicate the presence of atlantal zygapophyses as in the *Ganocephala*.

There are three genera of *Diadectidæ*, one of which is now introduced for the first time. They are distinguished as follows :

I. Molar teeth in one series ;
  A distinct canine.......... .... *Diadectes*.
  No canine.................................... *Empedocles*.
II. Molar teeth in two series ;
  A canine..................................... *Helodectes*.

I am acquainted with six species of this family, two of each of the genera.

DIADECTES Cope.

Proceeds. Amer. Philos. Society, 1878, p. 505. American Naturalist, April 22, 1878.

The typical species of the genus has compressed teeth, with one end of the crown much more elevated than the other. In the lower jaw the inner extremity is the elevated one, and *vice versa*. There is a large tooth in the position of a canine in the inferior series, but it is not certain whether or not it is an incisor. A new species is now described which is intermediate

*These were first described in the American Naturalist, 1880, p. 304.

between the *D. sideropelicus* and the *Empedocles molaris* in the form of the molar teeth. The species are distinguished as follows:

Much inequality in the elevation of the extremities of the molars; lower tubercle small .... *D. sideropelicus.*

Extremities of molars not very unequal in height; lower tubercle large.. *D. phaseolinus.*

DIADECTES PHASEOLINUS Cope. sp. nov.

This species is represented in my collection by the maxillary bones of three animals, and a portion of the mandible with most of the tooth line of a fourth. These fragments are of about the size of the *D. sideropelicus* and *Empedocles molaris.*

The molars possess a low cusp which is nearly in the middle of the tooth. Of the lower and external cusps, the internal is the wider and more rounded; when unworn it is as elevated as the external, but it is soon reduced by attrition. The external part of the tooth is somewhat narrowed, and there is no horizontal surface on either side of the median cusp, as in *Empedocles molaris.* The last maxillary tooth is rather small; preceding it are eight wide transverse ones, and then two less extended transversely before reaching the broken end of my best specimen. The anterior of these is elongate, and may be caniniform, but its apex is lost. External layer smooth; some wrinkles round the base of the median cusp.

The broken base of the molar bone is subround and small, and shows that that element is slender below the orbit.

The portion of mandible preserved is quite deep, and is incurved at the symphysis. But few of its teeth are preserved, and it is not possible to say how long the anterior ones with subround bases may have been. The molar whose crown is preserved does not differ materially from those of the maxillary series. The alveolar line does not retreat inwards from the external border as in *Empedocles latibuccatus,* resembling in this respect the *D. sideropelicus.* The external surface of the lower jaw is roughened by shallower and deeper small or minute pits closely placed.

Measurements.		M.
Length of series of eleven maxillary teeth		.075
Length of series of seven widest molars		.048
Diameter widest molar	anteroposterior	.006
	transverse	.016
Depth of mandible externally		.050
Width of mandible at middle		.026

It is possible that it may yet be necessary to refer this species to *Empedocles.*

EMPEDOCLES Cope.

Proceedings Amer. Philos. Soc., 1878, p. 516. American Naturalist, April 22, 1878; April, 1880.

I am acquainted with two species of this genus, *E molaris** and *E. lati-*

* *Diadectes molaris,* Amer. Naturalist, 1878, p. 565.

*buccatus.** The latter is represented by portions of two mandibles in my collection; the former by two or three skulls, with part of the mandible accompanying one of them. The difference in the forms of the mandibles is well marked. In *E. molaris* the dental series is parallel to the external border of the jaw; in *E. latibuccatus* the tooth line is deflected inwards from the border, leaving a wide space.

EMPEDOCLES MOLARIS Cope.

Diadectes molaris Cope. American Naturalist, 1878, p. 565.

The molar teeth are wider in this species than in any species of the family yet known. The internal and external extremities of the crown are about equally wide and equally elevated, and there is a low median cusp. A portion of the grinding surface both internal and external to the cusp is horizontal; the surface of this portion is wrinkled. The last molar is smaller than the others. The inner border of the maxillary bones forms a curved ridge on each side of the palate, which is separated by a groove from the vomer. The latter forms a median keel at the anterior portion of the palate, where it supports two rows of small conical teeth. The palatines have their prominent internal edges juxtaposed as far as the transverse line of the last molars. There they diverge a little, and extend as two nearly parallel keels to a prominent angle on each side, opposite the middle of the zygomatic foramen. There the inner borders cease to project, and are directed obliquely outwards to the inner extremities of the quadrate bones. The external borders of the pterygoids are more elevated than the internal. The median keel of the basisphenoid arises between the internal angles of the pterygoids above mentioned, and ceases before reaching the inferior border of the occipital condyle. The external border of the exoccipital is sigmoidally flexed.

It has occurred to me that the peculiar condition of the occiput described under the head of the family *Diadectidæ*, may be due to the loss of the basioccipital bone. It would be a remarkable coincidence if this accident should have befallen the only three crania which have come into my possession.

The anterior border of the orbit is above the anterior part of the fourth molar, counting from behind. The distinct incisive foramina are longitudinal and rather large. The anterior border is opposite to the fourth tooth counting from the first incisor. The nostrils look out laterally and a little forward; the united spines of the premaxillaries form a stout septum. The incisors are not more than three or four on each side (I cannot find the premaxillo-maxillary suture), and they form a regularly convex series. With the maxillaries, the entire dentition of one side forms a gentle sigmoid curve. The median incisors are the largest; the sizes regularly diminish until the smallest are reached on the anterior part of the maxillary bone. Posterior to this point they enlarge again. Their apices are not preserved.

* *Diadectes latibuccatus*, Proceed. Amer. Philos. Soc., 1878, p. 505.

The superior surface of the skull is only partly preserved in one specimen. This renders it probable that there is a crotaphite foramen as in the crocodiles, etc. The surfaces of the external cranial elements are finely pitted, or rather punctured.

Measurements.		M.
Total length of skull		.180
Width of skull at quadrates		.145
" " " origin of zygoma		.115
" " " incisive foramen		.056
Length of dental series to posterior extremity of incisive foramen, on curve		.090
Diameters of third molar from behind	anteroposterior	.010
	transverse	.021
Depth of mandible at fifth molar from behind		.048

Maxillary series of seven, and parts of the mandibular series of four, individuals, are in my collection.

HELODECTES Cope. Genus novum.

Maxillary bones of two species, which I refer to this genus, were found associated with many bones of appropriate size, among which are vertebræ of the type of *Empedocles*. The characters observable are generally similar to those of the *Diadectidæ*, where I accordingly place the genus. Its principal characters, the presence of two rows of teeth in the jaws, has already been pointed out. I may add that there is apparently a large tooth in the position of anterior incisor, in the typical species.

The species differ in the arrangement of their teeth, as follows:

Molar teeth of the two rows subequal in size, and equally numerous *H. paridens.*

Molar teeth of one row wider, and more numerous than those of the other .... *H. isaaci.*

HELODECTES PARIDENS Cope. Sp. nov.

The smallest species of the family, is of about half the linear dimensions of the *Empedocles molaris*. It is represented by a left maxillary and probably premaxillary bone, which are so far covered with the adhesive, hardened ferruginous mud of the formation, as not to expose a clean surface. The apices of all the teeth are broken off, so that the bases alone remain to indicate their number, form and positions.

Of the molar teeth proper I count six in the inner, and eight in the external row. The two series are close together, and are gently convex inwards. The bases of the teeth are wide ovals, transversely placed. In front of the eighth tooth of the external row (from behind), are two teeth without apparent mates of the internal row (possibly the latter lost). Then follows a tooth of each row, and in front of these another pair, the external being the larger. Anterior to these, the jaw is so split as to remove any teeth of the inner row, if there are any, and one large tooth of the external series stands at the extremity of the fragment. This latter exceeds the

other teeth in the length and diameter of its basal portion. From its position it is probably an incisor.

The anterior border of the orbit falls above the third tooth of the external row (counting from behind). The inner border of the maxillary bone is elevated into the ridge convex inwards, as in the other species of this family. The malar base of the zygomatic arch is a moderately stout vertical oval.

Measurements.	M.
Length of dental series	.062
Length of molar 6-8 series	.029
Width of the two molar series	.009
Vertical diameter malar bone	.018

The associated bones of the skeleton may belong to this or to the next species, or even to a small *Empedocles* whose teeth occur in the same lot. In the uncertainty of reference I do not describe them.

HELODECTES ISAACI Cope. Sp. nov.

Founded on a fragment probably of a maxillary bone, lacking both extremities, and considerably obscured by ferruginous deposit.

The characters are well marked, leaving no doubt that this species is distinct from those previously known. The bases of the teeth of one of the rows are much more extended transversely than those of the other, having the form of some of those of *Empedocles*. As in that genus, they shorten anteriorly. In the fragment, I count on this row, bases of nine teeth. In the other row, I can only definitely count three, which are opposite the second, third, and fourth of the other series (counting from behind). They are wide transverse ovals, about half the long diameter of the posterior teeth of the other series.

Measurements.		M.
Length of bases of eight larger molars		.032
Diameter of large molar	anteroposterior	.004
	transverse	.008
Length of three smaller molars		.012
Long diameter of a smaller molar		.004

This species is dedicated to J. C. Isaac, the discoverer of the first species of this family.

GANOCEPHALA.

Examination of abundant material shows the correctness of my anticipation (American Naturalist, 1878, 633), that the vertebræ of the large batrachian *Eryops*, would turn out to have the structure found in *Rhachitomus*. This genus then must be referred to the same sub-order as *Trimerorhachis*, and probably *Actinodon* Gaudry, which will be characterized by the segmented vertebral centra. If European authors are correct in stating that the vertebræ of the *Labyrinthodontia* have undivided centra, the sub-order above mentioned must probably retain the name of *Ganocephala*, with additional characters.

The identification of the scapular arch in *Eryops*, and of the pelvic arch

in *Eryops* and *Cricotus*, gives the following result: The glenoid cavity is an excavation in two coössified elements, of which the inferior and posterior is probably coracoid. The latter is then much smaller than in *Reptilia* and *Batrachia anura*, but resembles that of the salamanders. The scapular arch proper resembles that of the *Urodela*. The pelvis is intermediate between that of the anurous and urodelous *Batrachia*. There is no obturator foramen, and the common symphysis is deep. The humerus closely resembles that of the *Pelycosauria*, differing chiefly in the non-enclosure of the supracondylar foramen; and as in that sub-order, some genera possess condyles and some do not.

Prof. Owen proposed the order *Ganocephala* chiefly for *Archegosaurus*, but he included in it also the genera *Dendrerpeton* and *Pelion* (Paleontology, p. 182–3). This division has not been generally adopted, the genera mentioned being usually placed in the *Labyrinthodontia*. Of the eleven characters given by Prof. Owen in evidence of the existence of this order, one only does not belong also to the *Labyrinthodontia;* this is the absence of occipital condyles. On this account I thought that the group should be retained, but not as an order. Besides this group and the *Labyrinthodontia*, there were the types called *Microsauria* by Dawson, some of which have simple enamel, all agreeing in general characters, and differing from other Batrachia. I therefore combined the three groups into one order, the *Stegocephali*. (Proceedings, Academy, Philada., 1868, p. 209.) This order was most distinctly characterized in the Report of the Geological Survey of Ohio, Paleontology, ii, p. 354, 1875.

Von Meyer has given us enough of the characters of *Archegosaurus* to enable me to refer the forms of the Texan Permian to the same order. Prof. Owen, in his discussion of the affinities of that genus (l. c., p. 170), remarks, that the vertebræ and numerous very short ribs, with the "indications of stunted swimming limbs, impressed me with the conviction of the near alliance of the *Archegosaurus* with the *Proteus* and other perennibranchiate reptiles." As it is now well known that perennibranchiate batrachians belong to three different orders of the class (*Trachystomata*, *Proteida* and *Urodela*), the above expressions lose point, and especially as the characters mentioned as indicative of affinity are of the most subordinate importance, or as in the structure of the vertebræ, are totally distinct from what is found in those orders. When we read later (p. 173), that the fact that the superior "ossifications of the skull have started from centres more numerous than those of the true vertebral system, gives the character of the present extinct order of *Batrachia;*" we find that Prof. Owen has quite failed to perceive either the definitions or affinities of his new order. He commits an error in describing a distinct pubic bone; an element which Von Meyer states (Paleontographica, vi, 179, 1858) that he had not discovered. Von Meyer describes the coössified inferior elements of the pelvis as ischia. My numerous Texan specimens show that each of these bones includes both pubis and ischium:

In now defining the *Ganocephala* anew, I confine myself to characters

which I know to be common to the known genera. Some of them possess two occipital condyles. For the purpose of avoiding the multiplication of synonymes, I employ Prof. Owen's name.

Vertebræ consisting of centra and intercentra, the former not extending to the base of the vertebra, the latter not rising to the neural canal. The centrum consisting of two parts distinct from the superior neural arch; viz., a lateral piece (pleurocentrum), on each side. Atlas consisting of separate segments, the superior of which are not united above the neural canal, and the inferior (intercentrum) divided on the middle line, into two segments.

Genera. *A.* Basioccipital bone without condyles: *Trimerorhachis* Cope; *Archegosaurus* Meyer. *A. A.* Basioccipital condyles two: *Actinodon* Guadry; *Rachitomus* Cope; *Eryops* Cope.

All the above genera have well-developed neural spines except *Trimerorhachis.*

ERYOPS Cope.

Paleontological Bulletin No. 26, p. 188. Nov. 21st, 1877. Proceedings Amer. Philos. Society, 1877 (1878), p. 188.

In the essay above cited, the cranial characters of this genus were pointed out with some of those of the vertebræ. It remains to describe the other parts of the skeleton. Notices of some of these have already appeared in the American Naturalist for September, 1878 and May, 1880.

The largest element of the vertebra is the intercentrum. This, which occupies the entire inferior surface of the vertebra, is a segment, representing the sixth part of a sphere, with a slight central vacuity. The element representative of the centrum is wedged in between the superior external angles of adjacent intercentra, as in *Trimerorhachis.* These, as well as the intercentra, differ from those of that genus in their greater degree of ossification, which is so far complete as to greatly contract the *canalis chordæ dorsalis.* The central elements of opposite sides do not unite on the middle line below, although in contact. The neurapophysis is produced downwards and outwards, terminating in the simple diapophysis, with rib articulation. The inferior articular faces of the arch are two on each side, one for the central element in front, and the other for the one behind it. The whole is surmounted by a continuous neural spine, which is expanded at the summit, in the known species. The vertebræ do not differ much in different parts of the column. The cervicals are not distinguished in any way from the dorsals, but their anterior intercentra have more extensive costal surfaces, which give the inferior posterior border lateral angles. The diapophyses of the second and third cervicals are of reduced size. The neural spine of the axis is a little less elevated, and is longer anteroposteriorly than that of the third and succeeding cervicals. I do not possess an entire atlas free from matrix. Attached to the axis of this specimen are two elements which connected it with the skull, as they are separated from it only by closely fitting fractures. The elements are lateral, and each presents a semi-spherical articular face in front, and a long process with acute apex at right angles to it, posteriorly. These processes lie, one on each

side of the neural spine of the axis, above the position which would be occupied by its prezygapophysis; they represent the distinct halves of the arch of the atlas. At the superior base of each process near the edge of the articulation is a button-like tubercle, which represents a prezygapophysis; the inferior articular faces correspond with those of the occipital condyles in form but not in position, which is inverted. The inferior elements of the atlas are lost.

The intercentra are rather longer and more elevated in the sacral region. One only can be properly said to belong to the sacrum, and this is closely united with the one that follows it by a rough surface of contact. In old animals it may become coössified. What the relations to the intercentrum immediately preceding may be I am unable to state, owing to the condition of the specimen. A pair of caudal vertebræ are peculiar. Their intercentra are in contact throughout, excluding the pleurocentra. The latter rest above the intercentra, and between the inferior parts of adjacent neural arches. Each intercentrum supports a coössified chevron bone, and these, in the two vertebræ in question, become coössified with each other, forming a robust rod directed backwards, whose double base is perforated by the hæmal canal. This peculiar structure probably belongs near the extremity of the caudal series, as the anterior caudals observed in other specimens, are much like the dorsals.

The costal articulations are everywhere undivided, and have an obliquely vertical extension. The articular surface extends to the intercentrum in the *E. megacephalus*, forming a short superficial depression which enters from the supero-posterior border. The costal surfaces of the diapophyses become more robust anteriorly, and are more narrowed, especially at the middle and inferior portions, posteriorly. The diapophysis of the sacral vertebra is very robust, and presents a large tubercular face downwards, and a little backwards. The external side of the intercentrum about its superior angle is also covered by a large capitular facet, and the two facets support a sacral rib. This element is much more robust anteriorly than the true ribs, and its capitular and tubercular facets are distinct from each other, although they are separated by but a slight interruption. The body of the rib is plate-like, and is directed downwards and backwards, its union with the ilium being squamosal. The costal elements posterier to the sacrum diminish rapidly in size. From the size of the vertebræ in *E. megacephalus*, the tail is probably of medium length only.

The coracoid is but little incurved; its internal border is convex, and is roughened as though for cartilaginous attachment. Its superior portion forms a convex continuum with the scapula. The direct line or external face of the scapula extends in a nearly plane surface to the glenoid cavity, embracing a perforating foramen above the latter, precisely as in the *Pelycosauria*. Its surface is continuous anteriorly with a wide expansion forwards, whose fine inner border is continuous with that of the coracoid. This plate doubtless includes a third element, but its borders are not preserved, on account of the obliteration of the sutures. It is probably epicoracoid, as in the *Pelycosauria*. In its form it is less produced than in the known scapular arches of the latter.

The coössified pelvic elements resemble, in their compression below, the corresponding parts in the *Anura*. The ilia are, however, shorter and worn as in the *Urodela*. They are flat, and stand at right angles to the line of the ischiopubic symphysis. There is an open concavity of their inferior posterior free border, and a facet-bearing elevation on the inferior border, or that entering into the formation of the acetabulum. The latter is large and half as long again as deep. The anterior and posterior borders of the pelvis descend regularly to the inferior edge, forming with it a triangle. The ischiadic or posterior border is but little thickened ; the anterior, or pubic is flat in front and presents a reverted edge outwards. This expands prominently where it is joined by a ridge which bounds the acetabulum below ; it there contracts to an inferior apex. Beneath the anterior point of the acetabulum it is pierced by the usual foramen, which issues on the inner edge of the anterior face, just above the symphysis.

The humeral bones of this genus I probably possess ; but I have several forms between which I am not able to decide. They are in general like those of the *Pelycosauria*, but differ from them in not having an enclosed supracondylar arterial foramen, but only the buttresses of its enclosing arch. Two such forms I have already described,* and a third has been obtained from the French Permian by Professor Gaudry. One quite similar to the latter I have since obtained from Texas. Not having been able at first to determine the proper reference of these humeri, I suggested to Prof. Gaudry that his humerus belongs to one of the *Pelycosauria*, and he accordingly described it as *Euchirosaurus rochei*.† I now think that there is greater reason for believing that it belongs to a species of the same group as *Eryops* and *Actinodon*.

In all these humeri the extremities are expanded in different planes, and the shaft contracted. The articular surface of the proximal extremity is band-like and passes obliquely from one side to the other as in the *Pelycosauria*. The condyles are large, consisting of a globular portion and a depressed trochlea without ridges at one side of it.

The femora are very different from the humeri, but in much the same way as in the corresponding bones of existing *Batrachia*. There are no condyles at either extremity, but outlines of such, enclosing roughened surfaces. These look as though the bases of attachment of cartilaginous caps or epiphyses. The proximal extremity is convex, and is extended in one direction. One border, the anterior, is regularly gently convex ; the opposite arc is strongly convex near one end only. The articular face is in two planes, one larger than the other. The trochanteric fossa is at first shallow, and occupies the entire width of the bone, it narrows with the shaft downwards and the borders rise, one more than the other. The two join in a strong protuberance, which looks directly backwards, and may be called for the present the third trochanter. The shaft is keeled below and in continuation of the trochanter, to where it expands for the distal articu-

* Paleontol. Bulletin, 29, 1878, p. 520.

† Bulletin Soc. Geol. France, Dec., 1878.

lar extremity. The latter looks partly downwards, and is divided by a deep groove above into two parts representing the usual condyles. One of these is comparatively depressed, while the other has a massive superior crest, which makes its long axis vertical instead of horizontal, as is that of the other condyle.

There is considerable resemblance between this femur and that of *Dimetrodon gigas*, and in a less degree to that of *Clepsydrops natalis*, but both the latter have well developed condylar surfaces. They are also larger in proportion to the size of the rest of the skeleton, in the *Pelycosaurians* mentioned.

Further characteristics of this genus and of the species it embraces will be given at a future time.

TRIMERORHACHIS Cope.

American Naturalist, 1878, p. 328 (April 22). Proceedings American Philos. Society, 1878, p. 524.

This genus, as has been pointed out, differs from *Eryops* in the superficial character of its vertebral ossifications, and in the absence of ossified neural spines.

A well-preserved cranium, and portions of several others referable to this genus, furnish characters which have been hitherto inaccessible. They probably belong to the *T. insignis*, but this is not certain.

Generic Characters, etc.—The type of skull is that of the order of *Stegocephali* generally. The superior walls are thin, and are sculptured on the superior surface. The mucous grooves are distinct, but do not form a well-defined lyra. There is a groove which is parallel to the anterior borders of the orbit for a short distance, and which then turns forwards and then inwards. The dermal ossification is distinguished from that of the maxillary bone by a squamosal suture. A mucous groove descends to it obliquely forward from the superior quadrate region, and sends a branch at right angles to its anterior extremity to a point posterior to the orbit. Of superficial ossifications, the boundaries are difficult to determine, owing to the obscurity of the sutures. Enough can be seen to demonstrate the presence of supramaxillary, epiotic, and supraoccipital dermal bones. The nostrils are large and well-separated, and look upwards.

The teeth are acute, and of subequal size; their superficial layer is deeply inflected at the base.

The parasphenoid bone is wide posteriorly, but contracts abruptly, and extends forwards on the middle line. Owing to crushing of a part of the surface, I am unable to ascertain its anterior, or vomerine suture. The basifacial axis bone is quite narrow, and is edentulous. It is connected with the superior cranial walls by a vertical osseous plate on each side, which may represent alisphenoid, orbitosphenoid and ethmoid. The palatopterygoid arch is a longitudinally extended sigmoid, enclosing with the axial elements, an enormous choanoörbital foramen. It extends from the middle line below a short distance posterior to the position of the nostrils

outwards, and follows closely the maxillary bone well posteriorly. It then turns inwards, extending to the parasphenoid bone, with the wide portion of which it has an extensive contact. It then turns outwards as pterygoid bone, and rapidly narrowing, joins the inner distal extremity of the quadrate. It thus encloses a foramen with the quadratojugal bone, which is much smaller than the choanoörbital foramen. The posterior part of the inferior surface of the bones of this arch, not including the slender pterygoid portion, is roughened with hard nodules resembling teeth in material, and serving the purpose of such organs.

Two rod-like bones extend outwards and backwards from the posterior part of the parasphenoid and the basioccipital, which belong to the inferior arches. The anterior is the larger, and is bent backwards at an obtuse angle; its proximal extremity is a truncate oval. This bone occupies the position of the stapes. The second is extensively in contact with the basioccipital by its proximal extremity. It is curved backwards at its distal third. The occipital condyle is represented by a fish-like cotylus, which has a deep notch at its superior border.

The mandible has a short angular process, vertical by lateral compression. The symphysis is very short and the Meckelian cavity large, and completely enclosed.

The anterior cervical vertebræ consist of the same elements as the dorsals. The intercentra of the second and third vertebræ support capitular costal articulations, somewhat elevated above the surrounding level. The pleurocentra do not support the ribs, but the neural arches terminate below in diapophyses. There is a pleurocentrum in front of the second intercentrum, and above and in front of it a neurapophysis, which has no distinct diapophysis. Its superior portion is a subacute process which is not in contact with that of the other side, but is separated from it by a vertical osseous plate, which is probably the neural spine of the second vertebra or axis. This is similar to the structure already observed in *Eryops*, and the parts being in place, should explain those of that genus. The portion of the atlas which represents the intercentrum is divided into two lateral portions, each of which has the form of an entire intercentrum, i.e., crescentic. The intercentrum of a cervical of a large species of this group, is wider than that of the other vertebræ, and presents two articular facets anteriorly.

Specific Characters.—The skull is flat and rather wide, the length exceeding a little the transverse posterior diameter. The posterior borders of the orbits mark a point half way between the extremity of the muzzle, and the posterior supraoccipital border. The orbits themselves are of medium size, and are separated by a space about equal to their transverse diameter. Their form is a wide oval, with the long axis obliquely anteroposterior. The diameter of the external nostril is nearly half that of the orbit, and the form is similar to that of the latter. The interorbital and ethmoid regions are concave; the prefrontal regions are convex. The supraoccipital border is strongly concave; and the notch separating the epiotic angle from the quadrate angle is as deep as the supraoccipital. The

surface of the cranium is thrown into wrinkles which form no regular pattern, and which inosculate to a moderate extent, most so on the preorbital region. The anterior parts of the maxilliary and mandibular bones are marked with small pit-like impressions.

Measurements.	M.
Total length to quadrate angles measured on median line	.170
Length to supraoccipital border	.138
Total width posteriorly	.155
Width at orbits	.095
" between orbits	.021
" at nares	.062
" between nares	.030
Long diameter of orbits	.026
Transverse diameter of occipital cotylus	.012

This cranium is much shorter and wider than that of *Archegosaurus decheni*, and has the orbits more anteriorly placed.

CROSSOPTERYGIA.

ECTOSTEORHACHIS Cope, gen. nov.

Tribe *Crossopterygia;* family *Rhombodipteridæ* Traquair; sub-family *Saurodipterini* Huxley. Pectoral and ventral fins rather acutely lobate, with few or no radii on their external borders. Dorsal and anal fins unknown. Scales imbricate, rhombic, smooth. Ganoine wanting from top of head in specimens examined, but present on sides and inferior surfaces. Coronal suture distinct. End of the muzzle covered with separate scales. Distinct sub- and postorbital bones. Gular bones, an anterior azygus and two laterals on each side, the posterior the shorter. Teeth acutely conic, rather small; a few large ones at the anterior part of each jaw. Vertebral centra represented by osseous rings which enclosed a notochord.

This new genus is apparently nearly related to *Megalichthys*, and in a less degree to *Osteolepis* and *Diplopterax*. Pander, Miller and others represent the ventral fins of the two genera last named as not lobate, but sessile, a state of things entirely different from what is observed in *Ectosteorhachis*. The sub-division of the dermal bones of the muzzle is also rather characteristic of *Megalichthys*. From the latter genus it differs in the form of the vertebral centra. Both Agassiz and Huxley describe those of *Megalichthys* as completely ossified, and as biconcave. In *Ectosteorhachis* they are represented by annular ossifications resembling somewhat those of the stegocephalous genus *Cricotus*, but with a larger *foramen chordæ dorsalis*.

The elongate-lobate axis of the fins of this genus render it probable that those of *Megalichthys* present the same character.

ECTOSTEORHACHIS NITIDUS Cope, sp. nov.

This fish is represented by several specimens, the best preserved of which includes the head and body inclusive of the ventral fins. These form an ichthyolite nearly denuded of matrix, the inferior side being best preserved.

No indications of dorsal fin are to be found in the specimen, and those which exist must originate behind a point above the base of the ventral fins. The pectoral fins originate further behind the head than is usual. The ventrals are well posterior, and close together.

The skull is transversely fractured at the coronal suture, as I suppose it to be, which divides the front, just anterior to the point of attachment of the hyomandibular bone. At the antero external angles of the parietals, are distinct post-frontal bones of a sub-triangular form, which send a process posteriorly from their external angle. The hyomandibular presents a narrow convex external edge, and is directed backwards and downwards. It leaves a wide space posterior to the postorbital bones. Of the latter there are two, the inferior connected with the front of the orbit by a single wide, suborbital bone. The orbits are as much lateral as vertical, and are in front of a transverse line dividing the skull equally. The muzzle is broadly rounded, and is covered with rounded plates of ganoine. Several of these have median perforations. The opercular apparatus is obscured by matrix in the specimens; a small bone lies on the inferior part of the suspensorium on both sides, and may be the preoperculum. The top of the head behind the muzzle is entirely without ganoine layer in two specimens; its surface is smooth, or weakly finely ridged. On the other hand, the premaxillary, maxillary, mandibular and gular bones are invested with perfectly smooth ganoine.

The pectoral fins are quite wide, and their rays diverge exclusively from the inner border, and are very fine. The axial portion is thick and acuminate, and has no fulcra on the external edge, but is covered with quadrate and rhomboidal scales, of very much smaller size than those of the body. The axial portion of the ventral fins is not quite so large as that of the pectoral.

The scales of the body are quite large and overlap each other by both the free edges. Though their form is rhombic, the apex is rounded. The surface is ganoid, and entirely smooth. There are five rows between the internal bases of the ventral fins, and twelve between the external bases of the pectorals. The gulars of the posterior pair are about as long as those of the anterior. There are anteriorly one and posteriorly two rows of plates between the anterior gulars and the mandible.

This fish was probably three feet in length.

Measurements.	M.
Length of head to base of first distinct lateral body scale (posterior border of skull damaged)	.161
Length to base of pectoral fin	.180
" (axial) to canthus oris	.077
" of skull to coronal suture	.067
" " " anterior border of orbit	.021
Width " at " " "	.065
" of front between " " "	.036
" " at coronal suture	.029

Measurements.	M.
Width of skull at canthus oris	.145
Length of interior canine tooth	.006
Width between bases of pectorals	.092
Length of basal axis of pectoral	.060
" " " " ventral	.035
Width between bases of ventrals	.083
Diameters of exposed parts of an abdominal scale { fore and aft	.012
{ longitudinal	.015

The *Megalichthys hibberti* Ag., which this species resembles in some degree, is represented by authors as having the scales minutely granulated on the surface. The ganoine layer also covers the superior surface of the skull, a peculiarity which is not present in the *Ectosteorhachis nitidus*.

EXPLANATION OF FIGURES.

Figure 1.—*Skull of Eryops megacephalus* from above, one fifth natural size.

Fig. 2.—The same skull, profile.

Fig. 3.—The same from below.

Fig. 4.—Mandibular ramus from above, one-fourth natural size.

Fig. 5.—A large part of the vertebral column of a second specimen from the left side, one-fourth natural size.

Fig. 6.—The same from below.

Fig. 7.—Anterior view of atlas and axis, natural size.

Fig. 8.—Posterior view of a dorsal vertebra, natural size.

Fig. 9.—Inferior part of scapula with coracoid, of same animal, external side.

Fig. 10.—Same, interno-posterior view.

Fig. 11.—Pelvis of the same individual, left side.

Fig. 12.—Same, from front.

Fig. 13.—Same, from behind.

Fig. 14.—Same, from below.

Fig. 15.—Femur of same individual, from above.

Fig. 16.—Same, from below and behind.

Fig. 17. Proximal end.

Fig. 19.—Distal end.

Fig. 20.—Inferior view of skull of *Empedocles molaris*, one-half natural size.

Fig. 21. Posterior view of the same skull, half natural size.

Fig. 22-25.—Bones of *Dimetrodon incisivus*, one-fourth natural size, from a single individual.

Fig. 22.—End of muzzle, left side.

Fig. 23.—Lateral view of a large part of the vertebral column.

Fig. 24.—Thirteenth vertebra, lacking the summit of the neural spine, from behind.

Fig. 25. Fourteenth vertebra, lacking apex of neural spine, from front.

Fig. 26. Nineteenth vertebra of same skeleton, lacking most of neural spine, from behind, two thirds natural size.

Fig. 27. Sacrum of same from front, two-thirds natural size.

Stated Meeting, May 21, 1880.

Present, 7 members.

President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from Dr. Wm. Thomson, dated 1502 Locust street, Philadelphia, May 1, 1880.

Letters of acknowledgment were received from the Royal Observatory of Prag, dated April 24, 1880 (102, 103); Natural History Society of Newcastle-upon-Tyne, April 28 (103, 104); Brown University, in Providence, R. I., May 1 (105); Maryland Historical Society, Baltimore, May 11 (105); Smithsonian Institution, Washington, May 8 (105); U. S. Naval Observatory, Washington, May 10 (105); Hamilton College, Clinton, N. Y., May 8 (105); and the Davenport Academy of Natural Sciences, May 4 (105).

Letters of envoy were received from Hofrath Adam Freiherrn Von Burg, dated Vienna, January, 1880; the Society of Physics, Geneva, January 18; the Natural History Society, Marburg, January, 1880; and the K. Leopoldinisch-Carolinischen Akademie, Halle, a.-S. January 2.

A letter was received from Charles Kraus, dated April 26, 1880, Pardubitz-Bohemia, asking for the Proceeding of the year 1879.

A letter was received from the U. S. Naval Observatory, asking for Proceedings Nos. 5, 67, 68, 93. On motion it was referred to the Secretaries for action.

Donations were received from the Royal Society of New South Wales; the Observatories at the Cape of Good Hope, St. Petersburg, and Greenwich; Academies at St. Petersburg, Dresden, Dijon, and Brussels; Vereines zur Beförderung des Gartenbaues, Berlin; Anthropological Society, K. K. Geological Committee, and Hofrath Adam Freiherrn von Burg, Vienna; Editors of the Zoologischer Anzeiger, Leipsig; Royal Society, Göttingen; Zoological Gar-

den, Frankfurt, a.-M.; Editors of the Neues Lausitzisches Magazin, Görlitz; Natural History Society, Marburg; Physical Society, Geneva; Bureau des Longitudes, Society of Antiquaries, Annales des Mines, and Editors of the Revue Politique, Paris; Physical and Geographical Societies, Bordeaux; Editors of the Revista Euskara, Pamplona; Royal Institution, Royal Geographical Society, Meteorological Society, Editors of Nature, and Lords of the Admiralty, London; Glasgow Geological Society; Editors of the Canadian Naturalist, Montreal; Massachusetts Historical Society; Peabody Museum, and Museum of Comparative Zoölogy, Cambridge; Editor of the North American Entomologist, and Young Men's Association, Buffalo; Mr. Barclay and Mr. Henry Phillips, Jr., Philadelphia; the Bureau of Education, and Mr. Asaph Hall, Washington; Cincinnati Society of Natural History; State Historical Society, Madison, Wisconsin; Missouri Historical Society, St. Louis; and the National Museum, Mexico.

Mr. Henry Phillips, Jr., read a paper entitled, "Some recent discoveries of stone implements in Africa and Asia."

Prof. Cope made some remarks "On certain Tertiary Strata of the Great Basin."

In Vol I of the Report of the United States Geological Survey of the Fortieth Parallel, page 393, the able author, Mr. King, has described an extensive series of beds, including many laminated shales, which are found in the northern part of Nevada, as constituting an extension of the Green river formation west of the Wasatch mountains.* He states that they contain the same species of fossil fishes as those of the Green river epoch. I published the first notice of this formation, which I examined at Osino and at Elko, Nevada,† and described from it two species of fishes, which were referred to genera previously unknown, viz: *Amyzon* and *Trichophanes*. These genera have not been found represented in the fish fauna preserved in the Green river shales, which embraces eight genera and twenty-four species. But they occur in several species and specimens in the South Park of the Rocky mountains of Colorado, associated with the genera *Rhineastes* and *Amia*, neither of which has yet been found in the Green river formation. The first named is common in the Bridger, but in a different form, and the generic identity is not yet fully established. The *Amia* is

* l. c. I. p. 393.

† Proceedings Amer. Philos. Soc. 1872, p. 468.

represented in the Bridger by *Pappicthys*, but in the former genera the characteristic parts have not yet been seen in the South Park specimens, so that here also the determination of the genus is not final. It, however, remains that this fish fauna is different from that of the Green River beds, and the modern aspect of the genera points to an age even later than the Bridger. It is evident that the pertinence of this series of rocks to the Green River formation, asserted by King, cannot be maintained.

In the American Naturalist for May, 1879, I named the strata of this epoch that of the Amyzon beds, from the characteristic genus which it includes, and refer it to the later Eocene or early Miocene eras. Its fish fauna includes ten species, distributed, as follows: *Trichophanes* Cope, 3 sp.; *Amyzon* Cope, 4 sp.; *Rhineastes* Cope, 1 sp.; *Amia* L., 2 sp.

There is a series of calcareous and silico-calcareous beds in Central Utah in Sevier and San Pete counties, which contain the remains of different species of vertebrates from those which have been derived from either the Green River or Amyzon beds. These are *Emys*, sp.; *Crocodilus*, sp.; *Clastes cuneatus* Cope, and a fish provisionally referred to *Priscacara* under the name of *P. testudinaria* Cope. Dr. Hayden first directed my attention to these fossils, and I am indebted to the kindness of the director of the Museum of Salt Lake for the loan of specimens. I afterwards sent a collector to the region, and he obtained a number of fossils.

There is nothing to determine to which of the Eocenes this formation should be referred, but it is tolerably certain that it is to be distinguished from the Amyzon beds. In its petrographic characters it is most like the Green river, as it consists in large part of shales. The laminæ are generally thicker than those of Green and Bear Rivers. The genera Crocodilus and Clastes have not been found heretofore in Green River beds, although they are abundant in the formations deposited before and after that period. Until its proper position can be ascertained, I proposed that the formation be called the Manti beds. (See American Naturalist, April, 1880.)

The regions of the John Day River and Blue Mountains, furnish sections of the formations of Central Oregon. Above the Loup Fork or Upper Miocene, there is a lava out-flow, which has furnished the materials of a later lacustrine formation, which contains many vegetable remains. The material is coarse, and sometimes gravelly, and it is found on the Columbia River, and I think also in the interior basin. Prof. Condon, in his unpublished notes call this the Dalles Group. It is in turn overlaid by the beds of the second great volcanic outflow. Below the Loup Fork follows the Truckee Group, so rich in extinct mammalia, and below this a formation of shales. These are composed of fine material, and vary in color, from a white to a pale brown and reddish-brown. They contain vegetable remains in excellent preservation, and undeterminable fishes. The *Taxodium* nearly resembles that from the shales at Osino, Nevada, and on various grounds I suspect that these beds form a part of the "Amyzon Group" (American Naturalist, June, 1880), with the shales of Osino and of the South Park of Colorado. Below these, is a system of fine grained, some-

times shaly rocks of delicate gray buff and greenish colors, containing calamites, which Prof. Condon calls the *Calamite* beds. Their age is undetermined.

In the existing Geological maps of Oregon, the Coast range is represented as composed of Archæan rocks. This is a serious error. Prof. Newberry has already stated (U. S. Pac. R. R. Surveys, Vol. VI, pt. II, p. 29), that the fossils of the range are of an age not older than the Miocene. The unpublished notes of Prof. Condon, formerly State Geologist, state that the back bone of the Coast range consists of argillaceous shales which contain invertebrate and vertebrate fossils, frequently in concretions. Some of the latter are Physoclystous fishes, with strongly ctenoid scales. To this formation, Dr. Condon gives the name of Astoria shales. Above this is an extensive tertiary deposit, rich in Mollusca, which is usually interrupted by the central elevations of the mountain axis. Prof. Condon refers this to an Upper Miocene age, under the name of the Solen beds. On the flanks of the mountains, this is overlaid by a pliocene formation, containing some of the fossils of the Equus beds of central Oregon. This is both underlaid and overlaid by basalt, and other volcanic products.

Dr. Hayden made a few remarks further illustrating the same subject.

The Report of the Board of Officers and Council was submitted.

Mr. Eli K. Price, Chairman of the Committee on the Michaux Legacy, reported that the copy of the portrait of Mr. Michaux, as ordered by the Society, had been executed, and that he had inspected the same at the rooms of the Society; that the likeness was good and that after certain changes in the background that he would recommend its acceptance by the Society.

Pending nominations Nos. 904 and 909–917, and new nominations Nos. 918 and 919 were read.

And the meeting was adjourned.

Some recent discoveries of stone implements in Africa and Asia. By Henry Phillips, Jr., A. M.

(*Read before the American Philosophical Society, May* 21, 1880.)

Within the last few years the science of Archæology has received many additions through discoveries of stone implements and weapons in the cradle lands of the human race. A lithic age (whether exclusively so or not) seems to have existed in the dominions of the Pharaohs, and in the home of the Vedas, as well as in the rest of the habitable world. To exhibit a short résumé of what has been lately found in Asia and Africa is my object this evening.

In the Bulletin of the Egyptian Institute for 1869, '70, '71, there is much interesting and important matter relating to discoveries in Egypt. At the meeting of the Institute held in December, 1869, M. Lepsius stated that, acting upon information received from M. Lenormant, he had visited the place of an alleged find of stone implements in the neighborhood of Thebes. That he had found them in that place by the thousands; that in fact they were scattered in profusion throughout the entire desert. M. Arcelin, a German dwelling in Upper Egypt, reported that he had found similarly formed implements in deposits later than the tertiary period.

At the seance of April, 1870, Dr. Gaillardot referred to the discoveries reported by M. Arcelin at Cairo, of flint implements, of whose origin, use and authenticity, there could not be the faintest suspicion of doubt. These were found by Mariette Bey in the tombs at Saqqarah, together with ornaments formed of cockle shells. It seems, however, that these relics are not of the oldest stone age, but may be as recent as the historical period of Egypt.

In the tombs at Gourmah, which come down so late as the eleventh dynasty, vast quantities of barbs are found, whose points are sometimes of wood hardened by the action of fire, and sometimes are made of silex or fish bones. It is a very remarkable fact, that in all the remains of Pharaonic antiquity even down to the tombs of the Grecian epoch, no metal arrow-heads have ever been discovered; it is the Grecian sepulchres that are the first to afford bronze points. The Egyptian implements are said to lack the patina which age generally bestows upon genuine implements. This has been urged against them as an argument to prove they were not of the era to which they were supposed to belong. But it is said, that the very oldest of all the primitive silex implements that have ever been found in Europe are likewise entirely devoid of patination, so that no inference can be drawn from this fact.

Zittel found in the Libyan desert vast numbers of flints which bore the appearance of having been operated upon by the hand of man at a period of great remoteness in antiquity. Many of them were found in the desert about twenty miles west of the Oasis of Achel. Stone implements were used by the ancient Egyptians in the process of embalming, and even to this day are still used as razors.

The existence of those at Helwan, on the Nile, nearly opposite the ruins of

Memphis, first became known about 1872, having come to the notice of Dr. Reil, the director of the Sanatarium at that place. He wrote to the Ethnological Society of Berlin, relating the circumstances attending their discovery, and placed a collection of them in the Boulak Museum at Cairo. "The nature of the materials composing the plateau at Helwan varies from layers of fine mud to beds of coarse, angular débris," writes A. J. Jukes Browne, Esq., in a communication to the Cambridge Antiquarian Society, read at the meeting, held November 12, 1877, "and, in the railway cutting, beds of sand and clay are to be seen banked up against the ridge of limestone which rises up out of this valley. "The surface of the plateau is generally composed of loose sand, or stones and sand in place, compacted by saline deposits from the thermal waters which here permeate the soil; and it is upon these surfaces, worn into irregular ridges or hollows, that the flint flakes and tools are generally to be found. They do not occur below the surface except where they have been covered up by subsequent sand drifts. In excavating these sand drifts, implements have been met with at various depths, but none have ever been found in the beds of mud and sand which have been brought down by the streams and are exposed in the cuttings and diggings alongside of the railway. The normal position of the implements is, therefore, upon the surface of the plain; but it is to be noticed that they chiefly occur overlooking the greater depressions where the hardened ground may have existed as a surface for many hundreds, or perhaps thousands, of years; and there are at least five of these spots where the flakes and implements occur in such abundance as to suggest the idea that these were the actual localities where the work was carried on, the very manufactories where the tools of the period were made. The probability that such is the case is increased by the fact that the form of the flakes and the nature of the instruments differ considerably at each of the five places referred to. * * *

"The principal forms that were found, were lance-heads, arrow-heads, saws, long scrapers, thick scrapers, short knives, worked flakes, large flakes, small flakes and one triangular tool. No heavy weapons were found at Helwan, such as hammers, adzes, &c., but parallel cases have occurred where assemblages of small flakes and scrapers have been found at certain spots as if manufactured there, while there is an entire absence of celts, and the larger kind of instruments. Mr. Sketchley states that there is a great resemblance in shape between the Egyptian and the small Suffolk implements. The Helwan lance-heads are good specimens of flint work, the whole surface being worked over, and the sides chipped into serrated edges; they are about three inches long, and the base is squared and thinned off for insertion in the handle. The best arrow-heads are also well made, being of an elongately lanceolate form, the tag end exhibiting two small nicks for the purpose of binding it on to the shaft, in the same way as some of the American arrow-heads were secured.

"But the saws are the most curious and interesting of the Helwan implements; they vary from two to four inches in length, with one side or edge

nicked into wide or narrow teeth, and in some cases cut into a graduating series from large to small teeth. The teeth are often much polished, and sometimes more or less broken as if by dint of hard service, while in some of them both sides are worked into serrations, one edge being more broken than the other, as if it had been used up, and the other side had been chipped out in order to refit the instruments for service.

"The knife-like implements occurred in special abundance, varying in length from one to nearly two inches, but the greater number being about an inch and a quarter long. A few of them are almost semi-lunar in shape, and are similar to those used by the Esquimaux; in the rest, one end is left blunt, and the other brought down to a point, which is generally very sharp.

"Flakes were found at many places in great profusion, together with many of the cores from which they were struck. Almost all the flakes seem to have been utilized, and those that could not be converted into saws or knives were chipped, and evidently used in some way or other."

Mr. Browne has given a very long description of these implements from which I have extracted the foregoing statements. His paper is full of valuable matter, and deserves a careful perusal. He afterwards enters into the discussion of the problem of the antiquity of these flakes and implements, and takes the ground that their occurrence on the surface in no wise prevents them being referred to a remote age, for the reason that in Egypt the surface has probably remained unchanged for a very long period of time. In tombs of the era of the Ptolemies, flint weapons have been discovered, but these cases, Mr. Browne states, are very rare, and those which he saw in the Boulak Museum, "are different in type, and more modern-looking than the Helwan flints. Others which have been found in the neighborhood of Thebes are of a more antique and palæolithic appearance. Sir John Lubbock and others are of the opinion that the implements from Thebes are prehistoric, even as regards a land like Egypt, whose known annals extend backwards over so many thousand years."

The transition from Egypt to Palestine is not an abrupt one, and in the latter country relics of the stone age were discovered, in 1870, at Beth Saour, by Mr. Louis Lartet. Large quantities of stone implements of all kinds were found at this place, of which the bulk were fashioned into the form of knives. One notable exception, however, was a discoid flint resembling the usual European palæolithic type; there were also a needle and an arrow-point formed of bone.

Mr. Lartet is led to believe, from his observations of the locality and of the nature of the find, that there existed formerly at this place, a manufactory, where the fabrication of flint weapons and implements was carried on, such as has been found to exist in many parts of Europe. Since 1870, there have been found at Beth Saour, in addition to the types already spoken of, many knives, scrapers, large graters, bodkins, saws very regularly toothed, chisels which had been polished on stone, and hatchets. With these were mixed deposits of yellow pottery, very roughly made by hand and illy

baked, resembling in the bands, stripes, dots, &c., which constituted their ornamentation, the work of the neolithic period.

In the Troad in Asia Minor, at a town known as Hissarlik, very numerous stone implements have been discovered, of types and shapes analogous to those usually met with in Europe, and are all fabricated of the same rocks that occur in Turkey, Greece and the Archipelago. For example :

Serpentine from Megara, Corinth, Delphos, &c.

Jadeite from Thebes, Althea, Laconia, &c.

Dionite from Sparta, Kleone, Amphyceà, &c.

Amphibolites from Lemnos, Archæà and the Peloponnesus.

Syenite from Myceuæ.

At this latter place Dr. Schliemann reports the discovery of thirty-five arrow-heads of obsidian whose shape was similar to those used in North America.

It is stated that in the museum of the evangelical seminary at Smyrna, there are sixty different implements of stone which have been found in Lydia and Phrygia, of which some were polished, others not. The forms of the hatchets and of the hammers were similar to those previously discovered in Greece. Mr. Pappadopoulos avers that the whole region of Iconium is rich in relics of the stone age, and also that there are abundant vestiges in various lakes of Asia Minor of lacustrian habitations, not unlike those heretofore known in Switzerland.

In Northern Africa stone implements have been found, especially at Khenchela in Algeria. Here M. Jullien discovered quantities of worked flints, generally of large size, although, for the most part, broken. In this instance the finds occurred on the surface of the soil.

Signor Bellucci found in thirteen different portions of the realm of Tunis, no less than 2982 stone implements, being knives, arrow-heads, discs, sling-stones, scrapers, bodkins, beaters, &c. From the surroundings he drew the inference that a workshop for manufacture of stone implements had existed near Tunis.

Messrs. Fraas and Zittel report, severally, similar discoveries in Libya and the Libyan desert. Here the implements were associated with the remains of quaternary animals. Mr. Fraas attributed the worked stones which he found in Libya to the hand of man.

A large collection of stone implements from the Cape of Good Hope, came, a few years since, into the possession of the learned Dr. John Evans, F.R.S., F.S.A., &c., of Hemel Hempstead, England, of which he has been kind enough to write for me the following description : "They appear to be of two different ages, some being apparently palæolithic and closely resembling in form those of the European river gravels and those in quartzite from the latente deposits of Madras ; and others neolithic. Among these latter are numerous flakes of basalt, probably lance-heads, and some well wrought small spear-heads in flint. There are also hammer stones, both perforated and with recesses on one or both sides (possibly these may be more of the nature of mortars), and the usual 'digging stones' for weight-

ing pointed sticks. The palæolithic implements, if such they really be, are scarce. I have one very fine specimen from Proceso Fountain, Victoria, West. It is not of flint but formed of some hard metamorphic rock."

On the 30th of November, 1878, Mr. V. Ball read before the Royal Irish Academy, an essay "on the forms and geographical distribution of stone implements in India," in which country he had resided several years. He goes into the subject at considerable length discussing the various finds in (1) Madras, (2) Hyderabad and the Berars, (3) the Central Provinces and Bandelkhand, (4) Rajputana and Central India, (5) Bombay, (6) Sind and Beluchistan, (7) Bengal and Orissa, (8) Assam and adjoining countries, (9) Burmah, (10) Andaman Islands, (11) Sumatra and (12) Java. As a rule these implements are of the usual types, some, however, in Bandelkhand being evidently symbols of the *Lingum*, some being perforated stones; sometimes they are "well-shaped knives," discoidal objects, flakes and arrow-heads, all palæolithic (only one *polished* celt having been found in the Madras presidency), and a very few polished celts approximating to the unshouldered Burmese forms have been discovered in Assam. In the Burmese implements, however, the cutting surface has a chisel-like edge, while the Assamese tools have the edges ground down on both sides. In the Andaman Islands at the present day, Mr. Ball states, there inhabit a race of people who manufacture flakes from flint pebbles. "The Burmese call these implements *mo-jio*, thunder chain, or thunder-bolt, and believe that they descend with the lightning flash. It is supposed to possess many occult virtues, one of the chief of which is to render its wearer invulnerable, and many an unlucky *mo-jio* has succumbed to the popular test, which is to wrap it in a cloth and fire a bullet at it at short range. If the man misses the cloth the authenticity and power of the charm is at once established: if the stone is fractured it is held not to be a real *mo-jio*. Other less severe tests are also applied. Fowls, it is supposed, will not venture near rice on which a real *mo-jio* is lying; fire will not consume a house that contains one; a plantain tree cut down with one will not sprout again; and last, but not the least in esteem, the owner of a real *mo-jio* can cut a rainbow in half with it."

In Java a considerable series of chipped implements and polished celts has been found, "which have been reported on by a commission appointed for the purpose by the French Academy of Science."

Mr. Ball (p. 399) calls particular attention to a ring stone, too heavy for a spindle whorl or net sinker, and which he believes was really a weapon of offence to be grasped in the hand and used, as he expressed it, as a sort of "knuckle duster," in an encounter between men and wild animals. The chief point of interest about it is its very close resemblance to forms which have not uncommonly been met with in Europe, and likewise in Pennsylvania, Virginia and other parts of North America.

Accompanying Mr. Ball's paper is a map of the geographical distribution of stone implements in India. "The chipped quartzites occur throughout a vast area north and south from Sangor to Madras, east and west from Raniganj in Bengal, to Neemuch in Rajputana. Even

in far distant Java implements of a somewhat similar character have been met with; a fact of considerable interest pointing to a prehistoric connection. Flakes and cores are limited in their distribution to the area which extends north and south from Kerowlie in Rajputana, to Peyton on the Godaveri, in Bombay, and east and west from Singhbhum, in western Bengal, to Sukkur on the Indus, in Sind, and still further even to Gwadar, in Beluchistan. The polished celts extend from Upper Assam to Singhbhum, in Bengal, and from the Irawadi Valley, in Burmah, to Jabalpur, in the Central Provinces."

The map is colored to show these distributions respectively for each class in the order above referred to, light pink, light purple, and light blue. Mr. Ball offers two theories to account for this distribution of flint implements; one, that from a central interior point spread forth successive waves of emigration at different stages of civilization; the other, to which he inclines, was that the central area was a point of convergence rather than of divergence, basing his opinion on the fact that the manufactures become more abundant, and exhibit greater skill in proportion as we recede from this central area. A fact tending, in his judgment, to corroborate the notion that India was once an island, which gradually arose from the ocean at a period subsequent to its first being inhabited; that as the central parts of the country became accessible to wanderers from the surrounding quarters, with a knowledge of their respective arts, were thrown more in contact with each other, becoming the ancestors of some of the widely distinct races now living in India." Mr. Ball adds to his paper a list (covering twelve pages 8vo), of the localities in India where ancient stone implements have been discovered, and I would call your attention to the whole article from which these extracts (referring to India) have been taken as being carefully written and of great interest and importance. (Proceedings of the Royal Irish Academy, Dublin, Vol. 1, Ser. ii, No. 13, April, 1879.)

In the opinion of some writers of prominence and ability, the very existence of a stone age, *per se*, has been doubted, and the suggestion thrown out, which is plausible enough, that lithic implements, &c., were used in connection with others of metal which have not survived to modern times. It is not my wish to enter into any controversy respecting this much vexed question. My only object in the present instance has been to gather into one paper valuable facts, at present dispersed and scattered.

[NOTE.—At the Congress of Archæologists, in 1872, the Marquis de Vibray, exhibited a collection of stone implements, &c., found in Japan, amounting in all to sixty-seven. Of the hatchets many were perforated, and the types all bore resemblance to similar ones found elsewhere. The chief material of which they were formed was *jade*, but other stones were also used, including *obsidian*. The age of these objects could not be satisfactorily determined, nor what the relative civilization of Japan was in what seemed to be a polished stone age.

Within the past year (1879) dolmens have been opened in Japan in which stone arrows, &c., have been found. It is stated that the shell mounds at Amori contain bones of monkeys, deer, boars, wolves, and dogs, with not a few remains that plainly point to the former prevalence of cannibalism. In Cochin-China, the French aggressions have led to the discovery of stone implements, undoubtedly fashioned by the hand of man, among pottery, shells, and human and animal remains.]

Stated Meeting, June 18, 1880.

Present, 9 members.

President, Mr. FRALEY, in the Chair.

Mr. Wm. B. Rogers, Jr., a newly-elected member was introduced and took his seat.

Letters accepting membership were received from Joseph A. Murray, dated Carlisle, Pa., May 31, 1880; and from Ogden N. Rood, New York, May 10.

Letters of acknowledgment were received from the Royal Zoölogical Society, Amsterdam, dated June 2, 1880 (104); and the Royal Geological Society of Ireland (104).

Letters of envoy were received from H. Scheffler, dated Braunschweig, April 30, 1880; the Board of Commissioners of the Second Geological Survey of Pennsylvania, May 20; Mr. Frederick Fraley, Philadelphia, June 16; and John Hay, Assistant Secretary of the Department of State, Washington, May 22.

A letter was received from the Librarian of the Cincinnati Public Library, dated May 24, 1880, requesting to be allowed to buy certain volumes of the Transactions of the Society. The matter was referred to the Librarian with power to act.

A circular letter was received from the Smithsonian Institution, dated June 1, 1880, asking certain questions concerning the condition of the Society and its Library.

Donations for the Library were received from the Bureau of Mining, Melbourne; the Governor General of India; Academies at St. Petersburg, Berlin, and Rome; Observatory at Prague; Bureau of Statistics, Stockholm; Editors of Flora Batava, Leyden; Dr. Hermann Scheffler, and the Editor of the Zoologischer Anzeiger, Leipsig; M. A. Delesse, and the Editors of the Revue Politique, and Annales des Mines, Paris; Commercial Geographical Society, Bordeaux; Editor of the Revista Euskara, Pamplona; R. Astronomical Society, Victoria Institute, and Editors of Nature, London; Essex Institute, Salem; American Journal, New Haven; Brook-

lyn Entomological Society; American Chemical Society, and Editors of the American Entomologist, New York; Rensselaer Polytechnic Institute, Troy; Editor of the North American Entomologist, Buffalo; Zoölogical Society, Franklin Institute, Editors of the Medical News, and the American Journal of Pharmacy, Mr. Henry Phillips, Jr., Dr. F. V. Hayden, Mr. Chapman Biddle, and Mr. Benjamin H. Smith, Philadelphia; Mr. Peter Sheaffer, Pottsville; Board of Commissioners of the Second Geological Survey, Pennsylvania; Peabody Institute, Baltimore; Wabash College, Indiana; Col. Chas. E. Jones, Augusta, Georgia; Geographical and Statistical Society, and Editor of the Revista Cientifica Mexico; and Mrs. Ellen L. Schott.

Mr. Blodget made the following remarks upon certain features of Industrial Migrations as shown in the manufactures of Philadelphia.

The development of many of the industries of Philadelphia presents characteristics strikingly resembling those of nations conspicuous in history for industrial prosperity. History as usually written affords but an imperfect view of the real causes of national growth, and we are led to infer that the employment of the people is altogether secondary and subordinate. One of the best of the more authentic and better works which should take the place of histories is a treatise by the Marquis De Uztariz, on the industrial economy of Spain, originally printed in 1724, and reprinted in England in 1751, by John Kippax, under the patronage of the Prince of Wales. It gives a vivid picture of the great industries in wool and silk which made Spain rich and prosperous before the gold of the New World was known. Seville, Granada, Cordova and Toledo became magnificent cities through these industries in wool and silk, and sent Spanish cloths and embroideries to every country of Europe. Seville alone had 16,000 looms, employing 48,000 persons, and maintaining directly 12,000 families, or 60,000 persons. But this statesman of that early period found that great misfortunes followed the neglect of manufactures, and that a false policy of taxation had transferred many of them to France and the Low Countries. He wrote earnestly in resistance of that policy, and struggled to restore the ancient splendor of those great cities. The Spanish ruling class was infatuated with the gold and silver of the American colonies, however, and the first great industrial migration carried what remained of them into the Low Countries, from which they were subsequently drawn partly into France, by the skill of Minister Colbert, and still later into England.*

*The origin of these industries of Spain is so forcibly told by Marquis De Uztariz that I quote from his chapter citing the laws of King Ferdinand, Ferd-

At the first examination I had the opportunity to make of the textile industries of Philadelphia, I was struck by the evidence afforded that they represented a migration and transfer which would soon attain much greater proportions, and which even then deserved public attention as an important interest. I published a list of mills in 1857, and again in 1858, writing frequently in regard to it, and reprinting the Census of 1860, of which I had the supervision so far as related to manufactures. In that year I had the opportunity to show to Mr. W. S. Lindsay, member of Parliament from a north of England district, the work of thousands, recently emigrated from Nottingham, Leeds and other manufacturing districts, claiming that a transfer of those industries was in progress which would have a great influence on the future of the United States. Again in 1870 the evidences became still more decisive and the rate of progress much more rapid, but it was reserved to the period from 1876 to 1880 to complete what must be regarded as the most striking and massive of the great historic movements which have, since the 15th century, carried from one nation to another the crown of ascendancy in textile industries. I am well aware that it will not be admitted in many quarters that this movement has gone so far as I claim. This point is not material, however, if the facts of rapid progress in that direction are conceded. No one can deny that the most important successes have attended the effort to establish the textile industries here, and that they represent an extent of employment of productive power in looms and machinery exceeding the most prosperous days of Seville or of Manchester.

The point of interest in the philosophic sense is this apparent relation of national development to these greater industries. It is singular that they have migrated as national supremacy has changed its place, or more probably that an enforced migration has been the chief agency in building up one country at the expense of another. Spanish prosperity may very naturally have been supposed to be inseparable from the Spanish race during the period in which Ferdinand and Isabella "published one hundred and

inand and Isabella, and the Emperor Charles V, as follows: "The ancient historians, more inclined to speak of battles, sieges, revolutions and other events "that make a noise in the world, than to transmit the publick measures in favor of commerce, take little notice of the provisions made for its encouragement by our great monarchs, who most distinguished themselves by their "wisdom in the arts of peace and war. King Ferdinand, the Pious was of this "class, and in his reign there is mention of one circumstance on this head, "that after he had rescued the city of Seville from the yoke of the Mohammedans in 1248, he settled there many artificers who are the basis of a profitable "commerce, which is alone attainable by good manufactories." Next, their Majesties, Ferdinand and Isabella, by statutes of 1478 to 1494, made various regulations in favor of manufacturers of silks, brocades and cloths, and the said Ferdinand and Queen Juana, his daughter, in 1511, "published 119 laws respecting the fabrication, dying and sale of cloths and stuffs, every one of which "tended to make improvements in these manufactures." Also, the Emperor Charles V., by statutes of 1528, 1549, 1552 and others, added a hundred further laws regulating these industries, but during this century the imposition of heavy internal taxes aided the transfer of many textile industries to Flanders, and in part to France.—*See Kippax's translation*, 1751, *Vol. I*, p. 196, &c.

nineteen laws respecting the fabrication, dying, and sale of cloths and stuffs, every one of which tended to make improvements in each of the several manufactures''; but two centuries later this industry had gone from Spain and from the Spanish race to countries in the north of Europe. From Europe to this country the transition is perfectly natural and easy, coming with the immigration which all the circumstances unite in inviting. It is not in opposition to race prejudices, but entirely in accord with them, that the crowded populations of French or English cities should bring with them the industries which found their best market here, and establish silk weaving, tapestries, damasks, and all forms of ornamented tissues in silk and wool, as well as the plainer fabrics which are more promptly introduced. It is certain that they are being so introduced, and with a degree of rapidity much greater than is usually supposed.

The elements of permanence belonging to this movement are, however, better shown in the transfer of English industries in wool and cotton, than in the silk and worsted of France and Germany. The English movement has been in progress for twenty-five or thirty years, with a preliminary or partial movement from the north of Ireland and extreme north of England fifty years ago. Hand loom weaving in linseys and colored cottons was the distinctive form here, while the cloth fulling and woolen cloth weaving from the west of England was common to the whole country. Closely following these was the carpet weaving, which originated in France, but was given a form better adapted to general use in the English ingrains, and one which transplanted here has been extended with great rapidity and success. Yet the weavers are English, and establishments whether of the smallest or of enormous magnitude represent English migrations chiefly, and bring with them all that English skill has attained, as well as add the most recent American peculiarities. The impression they make is very striking, that it is not any present commercial or business advantage that has brought them, and that the 6000 men of English birth which the carpet industry alone employs in Philadelphia, are greater than all the temporary circumstances that can surround this carpet industry as a business. Their presence creates many of these circumstances, and naturalizes the change.

In the hosiery and knit goods industry there is a large preponderance of English identity, as it may be said, of identity in machinery, in workmen and in proprietorship, but there is also a considerable share of German and French elements of each of these classes. The variety of fabrics and articles made in this manner is much greater than is usually supposed, scarcely an article of finished clothing being excepted. Shawls, scarfs, caps and head dresses, coats or jackets, sleeves, gloves, &c., with all forms of hosiery proper, enter into consumption in this country to the extent probably of forty millions of dollars in value yearly. Under the effect of recent developments, four-fifths of the supply required is now produced here, and with changes in design and adaptation constantly effected, the industry itself is much extended and enlarged.

These primary and necessary industries, as they may be characterized, are here as highly developed in ornamentation and artistic effect as many of the more costly textile fabrics. Once established on a basis of skilled artizans resident here the changes which are required for assimilation with the country are effected easily and without disturbing that basis, or weakening its identity. The German workman is not less a German or the English knitter not less a representative of English skill because of the new adaptations which he acquires here, or is directed to employ by a proprietor who uses steam power where hand power only was previously employed.

This age is as luxurious in some of its tastes and demands as any that has preceded it, but in others it is much more moderate. The costly royal cloths of Spain, rich of themselves and loaded with gold or silver embroidery, are no longer demanded by any market; and it is only in fabrics exclusively of silk that such obvious luxury finds an acceptable outlet. But what is wanting on the more costly is more than made up on the average quality of fabrics in universal use.

The relation of these industries to the prosperity of the cities where they exist, and to that of the nation or country in which they form a prominent feature of general business, is not less marked now than at any former period. And the adaptations of steam power, which now increase production enormously without impairing its quality, must invariably accumulate wealth more rapidly than was possible before steam was known. The 16,000 looms of Seville constituted a remarkable productive force for the age in which they flourished, and they may well be named with pride by the Spanish minister; but there are 30,000 looms driven by steam power in Philadelphia, producing a vastly greater aggregate of such fabrics as this age demands; and though inferior in costliness, it is probable that they are as productive in material wealth to the city as were the looms of that once splendid city of Spain.

If this is in fact the natural line of movement from one country to another of these greater industries, the matter is worthy of consideration on higher grounds than those which are merely commercial or industrial in the business sense. The evidence is too strong to admit of doubt that the industrial migrations, taking with them the foundation industries in wool, silk and cotton, have made this city of Philadelphia their chief point of destination; not exclusively, however, but with a liberal distribution in northern cities. They do not find so much to favor them in the factory towns of New England, to which only the workmen in like factories in England or on the continent find themselves adapted. These factories represent a different class, distinctly separated from the aggregations of skilled workmen in Lyons, Paris, Philadelphia and like large cities. They are in some respects higher and more advanced developments; but they rest on a more narrow basis. A factory or corporation may exist for twenty years in one locality without fixing there an associated business which would survive the stoppage of the one mill. But here it is the workmen and their looms that constitute the fixture. The mill and the steam power are a valuable

adjunct, but the work can go on without them. Nothing but the *Alcavala* of ruinous taxation, or the substitution of a tax on exports for the proper tax on imports, as was done under the corrupt rule of the monarchs who ruined Spain, can destroy indigenous or thoroughly nationalized industries such as these.

The foundation industries in wool, cotton and silk have come here to stay; they have come from England first, and next from Germany and from France; and they already furnish an addition of many thousands of trained adults, men and women, to the body of the population of the greater cities of the United States.

Mr. Phillips called to the attention of the Society the new Dictionary of the English Language which was now approaching its completion.

The first germ of the project grew out of a paper read before the Philological Society in 1857, by Archbishop Trench, on "Some deficiencies in our English Dictionaries." The Society, subsequently, in 1859, issued a "Proposal for the publication of a New English Dictionary," in which the general scope and method of the intended work were set forth. The heavy financial outlay requisite and other obstructing causes retarded the work till about three years ago, when Dr. J. A. H. Murray, President of the Philological Society and Master of the great Mill Hill School, in London, took up the management and infused a new vigor into the undertaking. The plan is to furnish a history of each word in the English language, with a quotation from some author in every century since its first appearance, thus showing the date of its entrance, and the progressive changes, if any, which have occurred in its form and meaning. According to the materials already in hand, giving a sentence for every citation, the Dictionary would fill seven quarto volumes of 2000 pages each, but the intention is to reduce the quotations, when it can be done, to a smaller compass, thus keeping it within the trivial limit of "7000 quarto pages of the size of Littré's French Dictionary, making a work one and a half times the size of that, or more than four times the size of Webster, say in four thick volumes quarto." The book will be published at the Clarendon Press, Oxford, and the intention is that it shall be completed within ten years. The first part of 400 pages containing the letter A is to be ready in 1882, the residue to follow at regular intervals until the whole is finished. The supervision of the reading for the Dictionary done in America, has been confided to our fellow-member, Professor March, of Easton, Pa., who has awakened and stimulated the interest in this country, so that from Maine to Oregon daily contributions of quotations are pouring in to the learned editor.

When finished, the Dictionary will be one of the great books of the world, a stupendous monument for all time to the industry, zeal and learning of the scholars of the nineteenth century.

A letter was read from Mr. Eli K. Price suggesting that

photographs should be taken from the portrait of Mr. Michaux, for distribution among prominent botanists and botanical institutions. On motion an appropriation of $25.00 was made for the purpose.

The Committee to attend the Centennial Celebration of the American Academy of Arts and Sciences at Boston, reported and was discharged.

And the meeting was adjourned.

Stated Meeting, July 16, 1880.

Present, 4 members.

Vice-President, Dr. LECONTE, in the Chair.

A photograph of Henry Armitt Brown, a late member of the Society, was received for the album.

Letters of acknowledgment were received from the Statistical Society of London, dated June 24, 1880 (103, 104); and the Royal Danish Academy, Copenhagen, June 7, 1880 (103, 104).

Letters of envoy were received from the Trigonometrical Branch of the Survey of India, dated Dehra Dun, May 5, 1880; the Meteorological Office, London, June, 1880; and the Department of the Interior, Washington, D. C., June 29, 1880.

A letter was received from Mr. Murray, Acting Secretary of the American Philological Association, tendering the thanks of the Association for the use of the rooms of the Philosophical Society, and for the courteous attentions received by the Association.

A postal card was received from the American Chemical Society, stating that they had not received No 104, of our Proceedings.

Donations for the Library were received from the Acad-

emics at Buda Pest, Copenhagen, Berlin, Rome, Brusselles, and Philadelphia; Editor of the Zoologischer Anzeiger, Leipsig; Société Vaudoise, Lausanne; Cav. Damiano Muoni, Milan; Editor of the Revue Politique, Paris; Society of Commercial Geography, Bordeaux; Editor of the Revista Euskara, Pamplona; Royal Astronomical Society, Dr. C. William Siemens, and the Editors of the Chemists' Journal, and Nature, London; American Journal, and Yale College, New Haven; Metropolitan Museum, N. Y.; Pennsylvania Historical Society, Franklin Institute, Journal of Pharmacy, and Medical News, and Mr. Lorin Blodget, Philadelphia; Mr. P. W. Shaefer, Pottsville; U. S. National Museum, Smithsonian Institution, and Department of the Interior, Washington, D. C.; American Philological Association; Dr. Robert Peter, Frankfort, Ky.; Editor of the Revista Cientifica Mexicana, and the Ministerio de Fomento, Mexico.

Prof. E. D. Cope presented a paper "On the genera of the Creodonta."

On account of the small attendance the election of members was postponed until the next stated meeting.

Pending nominations Nos. 904, 909 to 915, 917 to 919, and new nomination No. 920, were read.

And the meeting was adjourned.

On the Genera of the Creodonta. *By E. D. Cope.*

(*Read before the American Philosophical Society, July* 16, 1880.)

For the characters of this group of the unguiculate mammalia, the reader is referred to the fourth volume of the final Report of the U. S. Geol. Survey W. of the 100th Mer., under Capt. Wheeler Pt. ii, p. 72.

History. MM. Laurillard, Pomel and others have referred the European *Creodonta* to the *Marsupialia*, on account of the great similarity of the dentition. MM. De Blainville and Gervais have, on the other hand, regarded them as placental, a view which I have assigned reasons* for believing to be the correct one. M. Filhol has recently shown that the replacement of the dentition in *Hyænodon*, which has some affinities with

* Proceedings Academy, Phila., 1875. Paleontological Bulletin No. 20, Dec., 1875.

the *Creodonta*, is quite as in true placental *Carnivora*. Professor Gaudry has expressed the opinion that the *Creodonta* are the descendants of the *Marsupialia*.* I incline to maintain another view.

If we suppose that the *Creodonta* are the descendants of the *Marsupialia*, we must suppose that the *Insectivora*, to which they are related, are also the descendants of the *Marsupialia*, and this is on various grounds not very probable. The lower forms of unguiculate mammalia with small cerebral hemispheres are very much alike in important characters, and to these I have given the name of *Bunotheria*. I suspect that this group is as old as the *Marsupialia*, and may even have given origin to it. That it developed cotemporaneously with it in various parts of the world is evident.

Restoration. The Wasatch beds of New Mexico have yielded remains of more than a dozen species, which ranged from the size of a weasel to that of a jaguar. The Bridger beds of Wyoming probably contain as many species, which range from small size to the dimensions of a bear.

In general appearance, the *Creodonta* differed from the *Carnivora*, in many of the species at least, in the small relative size of the limbs as compared with that of the head, and in some instances as compared with the size of the hind feet. The feet are probably plantigrade, and the posterior ones capable of some degree of horizontal rotation. The probable large size of the rectus femoris muscle indicates unusual power of extension of the hind limb. They were furnished with a long and large tail. Probably some of the species resembled in proportions the *Mystomys* and *Solenodon*, now existing in Africa and the West Indies, but they mostly attained a much larger size. The habits of many of them were probably aquatic.

Classification. To the *Creodonta* I have referred,† on the information which we possess, the genus *Arctocyon* of Blainville. Professor Gervais has discovered that it possessed the very small cerebral hemispheres characteristic of the *Creodonta*. The olfactory lobes are large, and project far beyond the hemispheres, while not only the cerebellum, but probably the corpora quadrigemina, were exposed behind. The tarsal articulation and the posterior part of the mandibular bones are unknown, hence this reference is not certain. Professor Gervais‡ regards it, after Laurillard,§ as a marsupial, and establishes an especial family of the order for its reception. It is, however, more probable that its affinities are with the contemporary genera of flesh-eaters, *Palæonyctis* Blv., and *Pterodon* Blv., genera which have near allies among the American forms. *Palæonyctis* was the contemporary of the Coryphodons in the Suessonian period of Western Europe, and presents a strong resemblance to *Amblyctonus* in its mandible, the only part of the skeleton known. The posterior part of the ramus is not inflected according to Gervais, and he therefore does not refer it to the *Marsupialia*.‖ The nearest European representative of *Oxyæna* is *Ptero-*

* Enchainements du Monde Animal, 1878, p. 21.
† Report Capt. G. M. Wheeler, Expl. Surv. W. 100 Mer. 1877, iv, pl. ii, p. 88.
‡ Nouv. archives du museum, 1870, p. 150.
§ Dict. univ. d'hist. naturelle, ix, p. 400.
‖ Nouv. archives du museum, 1870, 151.

don, in which the form of the mandible also forbids a reference to the *Marsupialia*, as Gervais has remarked. Both genera are doubtless members of the sub-order of *Creodonta*. The genus *Hyænodon*, on the other hand, is not referable to the same group, for I find in a specimen of the *H. requieni* from Desbruges, preserved in the Museum of the Jardin des Plantes, that the scaphoid and lunar bones are coössified. Moreover the figure given by Professor Gervais* representing the brain of the originally-described type, *H. leptorhynchus* of the Miocene period, displays characters of the true *Carnivora*. The anterior part of the cranial cavity of the specimen molded is broken away.

It is possible that the genus *Diacodon* Cope belongs here also ; its species resemble slightly the *Marsupialia* in the inferior dentition, and are of small size.

The genus *Mesonyx*,† which I discovered in the Bridger beds of Wyoming, has the trochlear face of its astragalus completely grooved above as in the true *Carnivora*, and its distal end presents two distinct facets, one for the cuboid, and the other for the navicular bones. It represents on this account a peculiar family, the *Mesonychidæ*.

There are various degrees of development of the sectorial structure of the molars in this sub-order. In some of them, as *Didymictis*, only one of the inferior molars presents this structure ; in others two, and in others three. In one type, the last superior molar is longitudinal ; in others, it is transverse. In *Arctocyon* the superior true molars are tubercular.

I have heretofore‡ defined three families, the *Amblyctonidæ*, the *Oxyænidæ*, and the *Arctocyonidæ*. I now add the *Miacidæ* and *Mesonychidæ*. The definitions are as follows :

I. Ankle joint plane transversely.

True molars above and below tubercular; last superior not transverse.......................... .... *Arctocyonidæ*.
Superior true molars tubercular; first inferior "tubercular-sectorial"... *Miacidæ*.
Last superior molar trenchant, transverse: inferior true molars tubercular-sectorial............................. *Oxyænidæ*.
Last superior molar longitudinal; inferior true molars without developed sectorial blade...................... *Amblyctonidæ*.

II. Ankle joint tongued and grooved, or trochlear.

Inferior molars each with one conic tubercle and a heel ; no developed sectorial blade.............................. *Mesonychidæ*.

I now give the characters of the genera. All these are derived from examination of typical specimens. The opportunity of doing this I owe to the kindness of Messrs. Leidy, Gervais, Gaudry, Filhol and Lemoine.

* Loc. cit., pl. vi, fig. 5.
† Ann. Rept. U. S. Geol. Surv. Terrs., 1872, p. 550.
‡ Report Capt. G. M. Wheeler's Expl. Surv. W. 100 Mer, 1877, iv, pl. ii, p. 89.

Arctocyonidæ.

Premolars $\frac{4}{4}$; the first inferior one-rooted; the last inferior well developed .... *Arctocyon* Blv.
Premolars below, 4, the first two-rooted, the last true molar much reduced .... *Hyodectes** Cope.
Premolars below, 3, first two-rooted; true molars normal .... *Heteroborus*† Cope.

Miacidæ.

Inferior tubercular molars two, premolars four .... *Miacis* Cope.
Inferior tubercular molars one, premolars four .... *Didymictis* Cope.

Oxyænidæ.

I. Inferior molars without internal tubercles.

Molars, $\frac{4}{4}$ $\frac{3}{3}$; three sectorials in the lower jaw .... *Pterodon* Blv.

II. Inferior molars with internal cusps.

Molars, $\frac{4}{4}$ $\frac{3}{3}$; two last inferior molars tubercular-sectorial .... *Oxyæna* Cope.
Premolars $\frac{4}{4}$; three last inferior molars tubercular-sectorial; the fourth superior with a conic cusp and heel externally .... *Stypolophus* Cope.
Premolars $\frac{4}{4}$; three last inferior molars tubercular-sectorial; fourth superior premolar with a simple blade externally .... *Proviverra* Rütim.

Amblyctonidæ.

Fourth inferior premolar with a broad heel supporting tubercles .... *Amblyctonus* Cope.
Dental formula below, 3, 1, 3, 3. Fourth inferior premolar with a cutting edge on the heel .... *Palæonyctis* Blv.

Mesonychidæ.

Inferior molars seven .... *Mesonyx* Cope.
Inferior molars five .... *Patriofelis* Leidy.

Of the preceding genera it may be remarked, that the structure of the feet of *Pterodon* being unknown, it may be found hereafter to be necessary to remove it from the *Oxyænidæ*, although I do not anticipate that such a course will be necessary. *Palæonyctis* is only known by the mandibular dentition, which is very near to that of *Amblyctonus*. So also it is not certain, but only probable, that *Patriofelis* belongs to the *Mesony-*

* Type *Arctocyon gervaisii* Lemoine, Oss. Foss. des Envir. de Reims, 1878, p. 8.
† Type *Arctocyon duelii* Lemoine, l. c., p. 9.

chidæ of the same horizon and locality. The horizontal and geographical distribution of the species of these thirteen genera is as follows:

	Lower Eocene.		Upper Eocene.	
	N. A.	Eur.	N. A.	Eur.
Arctocyon primævus Blv		*		
Hyodectes gervaisi Lem.		*		
Heteroborus duelii Lem.		*		
Miacis parvivorus Cope			*	
" edax Leidy			*	
" vorax Leidy			*	
Didymictis protenus Cope	*			
Pterodon dasyuroides Blv		*		
" biincisivus Filh				*
Oxyæna morsitans Cope	*			
" lupina Cope	*			
" forcipata Cope	*			
Stypolophus viverrinus Cope	*			
" secundarius Cope	*			
" multicuspis Cope	*			
" strenuus Cope	*			
" minor Filh				*
" caylusi Filh				*
" pungens Cope			*	
" brevicalcaratus Cope			*	
" aculeatus Cope			*	
" hians Cope	*			
Proviverra typica Rütim		*		
Amblyctonus sinosus Cope	*			
" sp. no. 2†		*		
Palæonyctis gigantea Blv		*		
Mesonyx obtusidens Cope			*	
" lanius Cope			*	
Patriofelis ulta Leidy			*	

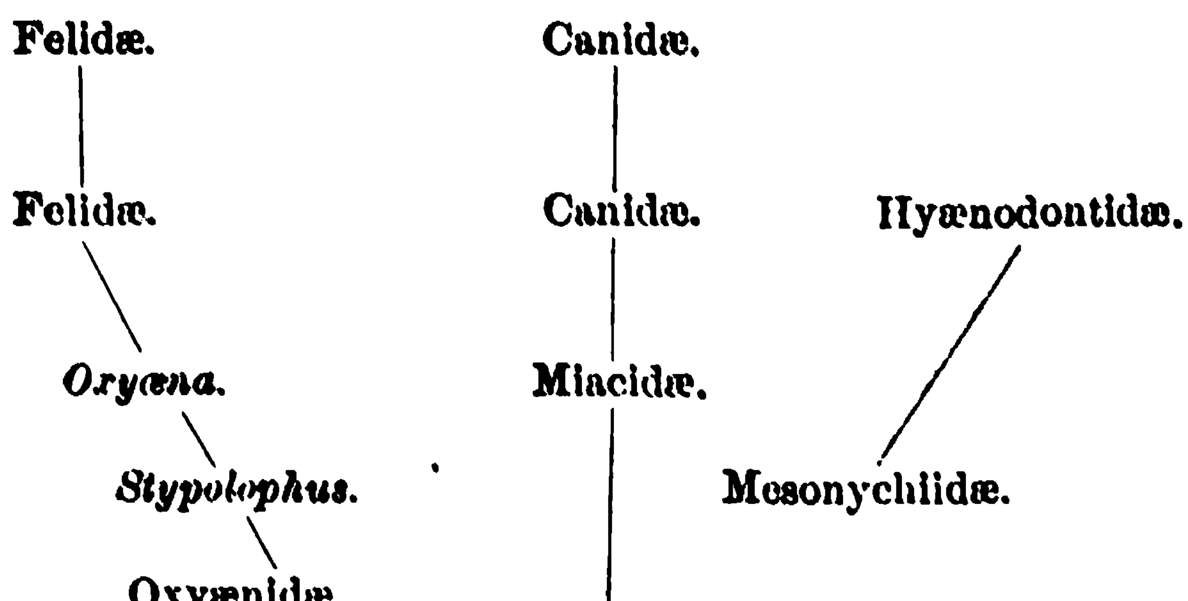
Phylogeny. It is among the genera above enumerated that we are to look for the ancestors of the existing *Carnivora*, excepting perhaps the seals, and even these were probably cotemporaries. In those genera without developed internal tubercles of the molars, we may look for the ancestors of the *Hyænodontidæ*, a family which early attained specialization at the expense of strength of structure, and did not survive the lower Miocene period. Such genera may be found in the *Mesonychidæ* as the later, and the *Amblyctonidæ* as the earlier types.

In distinguishing between the ancestors of the *Felidæ* and *Canidæ*, we naturally seek to recognize in each, an anticipation of the leading characters in the dentition which distinguish those families to-day. This consists, in the *Felidæ*, in the successive abbreviation of the true molar series from behind, so that ultimately two molars are lost, and the remaining or anterior one becomes transverse. On the other hand in the *Canidæ*, firstly,

† Represented by a mandible with teeth, from Meudon, associated with the specimens of *Palæonyctis* in the Mus. Jardin des Plantes.

the full number of true molars is retained in some genera, as *Amphicyon*, and only one lost in *Canis*. Secondly, the tubercular character of the posterior molars in both jaws in the *Canidæ* is distinguished from their sectorial character in *Felidæ*. Estimated by these tests the *Miacidæ* are clearly the forerunners of the *Canidæ*, and the *Oxyænidæ* of the *Felidæ*. In *Miacis* we have in fact a near approach to the dentition of *Canis*, in the lower jaw; while in the same part of *Didymictis* posterior abbreviation has commenced, reminding one of *Viverra*. In the *Oxyænidæ*, one degree of posterior abbreviation is seen in *Stypolophus*, where the last superior molar is narrowed and turned at right angles to the others. In *Oxyæna*, the process had advanced a step, for there are but two superior true molars, and the last of these is driven in, transversely. The first true molar is functionally sectorial in this genus, while the last premolar is the true sectorial of the superior series in existing *Carnivora*. In the inferior series there are only two true molars in *Oxyæna*, both primitive, or "tubercular-sectorial" in character. In existing *Felidæ* the second is lost, while the first undergoes great changes in becoming a specialized sectorial. The forms of the *Felidæ*, which are nearest, are the *Cryptoprocta*, and the *Proælurus* of Filhol, but they only follow after a wide interval. I have elsewhere discussed the successive steps in the evolution of the sectorial itself.* I have also pointed out† the successive shortening of the anterior part of the dental series in the *Felidæ* and other groups of existing *Carnivora*, which came later in time.

The following table will give an idea of these affinities, and the phylogeny to be derived from them:



Synonymy. Prof. Gaudry has united *Stypolophus* (*Cynohyænodon* Filhol) with *Proviverra*. After an examination of casts of Rütimeyer's types preserved in the Museum of the Jardin des Plantes, I retain them as distinct for the reasons given above. Mr. Bose in an interesting paper on this subject published in the London Geological Magazine for May and

* Proceedings Acad. Phila., 1875, p. 21.
† Felidæ and Canidæ, l. c., 1879, p. 169–170.

June, 1880, unites *Didymictis* with *Palæonyctis*.* Having examined the types of both genera, my conclusion as expressed in the preceding pages is very different. On the other hand, I have good reason for believing the species to which the name *Synoplotherium* was given, *S. lanius*, is really a second species of *Mesonyx*, of larger size than the *M. obtusidens*, and otherwise different. It is likely that some of the species of the Bridger formation, to which Marsh has applied generic names, belong to the *Creodonta*, and may belong to some of the genera described by myself. The fact that no generic definition accompanied the publication of those names, renders their use impracticable.

Stated Meeting, August 20, 1880.

Present, 4 members.

President, Mr. Frederick Fraley, in the Chair.

Mr. Joseph C. Fraley, a newly elected member, was introduced, and took his seat.

Letters of acknowledgment were received from the Royal Society, June 3 (100, 101, 102, 103); the Royal Society, New South Wales, June 14 (101, 102, 103); Royal Institution, July 12 (105); the Victoria Institute, July 10 (105); the Statistical Society, London, July 20 (105); Society of Antiquaries, July 21 (105); University Library, Cambridge, July 19 (105); the Museum, Newcastle-upon-Tyne, July 19 (105); New Hampshire Historical Society, August 12 (106 and List); New Jersey Historical Society, August 11 (106 and List); Essex Institute, August 12 (106 and List); Boston Public Library, August 14 (106 and List); U. S. Military Academy, August 13 (106 and List); Dr. C. H. F. Peters, Litchfield, A. of Hamilton College, Clinton, Oneida county, New York, August 17 (106 and List); American Ethnological Society, New York, August 12 (106 and List); Connecticut Historical Society, Hartford, August 18 (106 and List); American Antiquarian Society, Worcester, August 13 (106 and List); and from Dr. E. Jarvis, Prof. W. P. Blake, Dr. T. M. Drown, and Mr. W. B. Taylor (106 and List).

*I have just seen this paper, having already written what precedes this paragraph.

Letters of envoy were received from the Adelaide Observatory, June 3, 1880, and the Government of Victoria, Australia, Agent General for Victoria, June 8; Victoria Chambers (Westminster, S. W.), April 28, 1880.

A letter was received through Mr. Phillips from Mr. B. B. Diney, dated 3822 Market street, Philadelphia, July 16, accompanying a piece of the cog-wheel of the old Independence Hall Clock.

Donations for the Library were received from the Prussian Academy; Zoologische Anzeiger; Geographical Society of Paris; Annales des Mines; Revue Politique; Commercial Geological Society of Bordeaux; Belgian Academy; Nature; Franklin Society, Providence, R. I.; Cambridge Observatory; American Chemical Society, New York Academy of Sciences; American Academy of Sciences, Boston; Franklin Institute; Journal of Pharmacy; Medical News; American Journal of Science; U. S. Coast Survey; U. S. Geographical Surveys; Missouri Historical Society; American Antiquarian, Chicago; Bol. Min. de Fomento, Revista Scientifica, Mexico; Revista Euskara, Pamplona; Camoëns Celebration, Lisbon; Asiatic Society of Japan; Government of Victoria and New Holland Institute.

The death of Dr. Paul Broca, at Paris, July 10, 1880, was announced.

The death of M. Viollet le Duc, not previously noted, was also reported.

Communications were received from Prof. John J. Stevenson. 1. "Notes respecting a re-eroded channel-way;" and 2. "Notes on some features of the geology of Wise, Lee and Scott counties in Virginia;" each illustrated by three cuts.

Mr. Fraley reported the receipt of the last quarterly interest on the Michaux legacy, $132.12, due July 1, 1880.

The Publication Committee reported that they had seen and approved the drawings of fourteen plates for Prof. S. S. Haldeman's memoir on the Chickis cave relics.

And the meeting was adjourned.

Notes respecting a Re-eroded Channel-way. By John J. Stevenson, Professor of Geology in the University of the City of New York. (With three wood cuts.)

(Read before the American Philosophical Society, Aug. 20, 1880.)

The north branch of the Canadian river is formed near west longitude 104° 30′ at about 25 miles south from the northern boundary of New Mexico by two small streams, which rise in the Raton hills and drain much of the Trinidad Coal Field. Within 25 miles, the river enters a cañon, which deepens rapidly until, at 50 miles from its head, its nearly vertical walls are almost 1100 feet high, while the width of the gorge at the bottom varies from 150 to 800 feet. Thus far no important tributary enters the river in the cañon, but the petty side-cañons show that at some time or other much water must have flowed in from the Canadian plains. At probably 50 miles from the head of the cañon the Canadian river is increased by the Mora river, which rises on the east slope of the Las Vegas range and flows eastward to the Canadian. Its cañon becomes close at a little way south from Fort Union, and thence to the Canadian the river flows at the bottom of a gorge with bold vertical walls, becoming higher as the stream descends, until at the mouth of the cañon they rise to 1090 feet above the "bottom," where some half savage Mexicans gain a scanty livelihood by cultivating little patches of corn and melons.

Both cañons have the hard Upper Dakota sandstone as their rim, and that rock is the surface rock of the plains between the cañons, where a few relics of the Middle Cretaceous beds remain, protected by a plate of basalt which covers the Low Mesas or Table hills.

An extinct volcano, at 7 miles east from Fort Union, forms the southern extremity of the Turkey mountains—the Gallinas hills of Dr. Newberry's San Juan report—a curious qua-qua-versal, which deserves much closer study than could be given to it by either Dr. Newberry or myself. The volcano has been visited by Dr. Newberry, Dr. LeConte, Dr. Hayden and the writer. The crater still retains its form and the rim is broken only on the southern side, an imperfection due, perhaps, in some measure to erosion, but in greater part to the pressure of the lava. The eruption to which this mountain owes its origin occurred in the later Tertiary, and the lava is basaltic.

The basalt extends northward but a very little distance and the flow was toward the south through the breach in the crater. The lava was followed from the breach directly to the Mora cañon, the passage beginning along an arroyo or dry water course, where the basalt rests on Upper Dakota sandstone, though occasionally a little débris intervenes. At one locality, some tufaceous limestone, characteristic of the Santa Fé Marls, belonging to the Loup River epoch, is included in the débris.

Entering the Mora cañon, the basalt followed the gorge to its mouth, and was in such volume as to flow up the Canadian cañon to a distance of near-

ly three miles. How far it went below the mouth of the Mora cañon was not ascertained. The continuity of the flow is distinct throughout and the general features of the rock in the Canadian cañon are the same with those observed in the crater itself.

A solid crust forms quickly on the surface of cooling basalt. It is probable, therefore, that the Mora river was not long displaced; but that it, as well as the Canadian, soon regained its channel and began once more the work of corrasion. The features shown in the cañons are of no small interest, for the extent of erosion prior to the basalt flow is as clearly exhibited as is the extent of the erosion since that event. The features are best studied in the Mora cañon, at the mouth of which the following measurements were obtained:

1. From river surface to bottom of basalt................ 230′
2. " same to top of basalt........................... 620′
3. " " brink of the chasm.................... 890′
4. " " top of wall.......................... 1090′

The chasm is therefore 230 feet deeper than when the basalt flood took possession of it.

As the present cañons do not wholly coincide with the ancient gorges, the numerous curves exhibit the base of the basalt sheet very satisfactorily. The old valley of the Mora was benched or slightly terraced, so that the lava rests against a wall of sandstone, and overflows the bench of which that is the escarpment, as is shown in fig. 1:

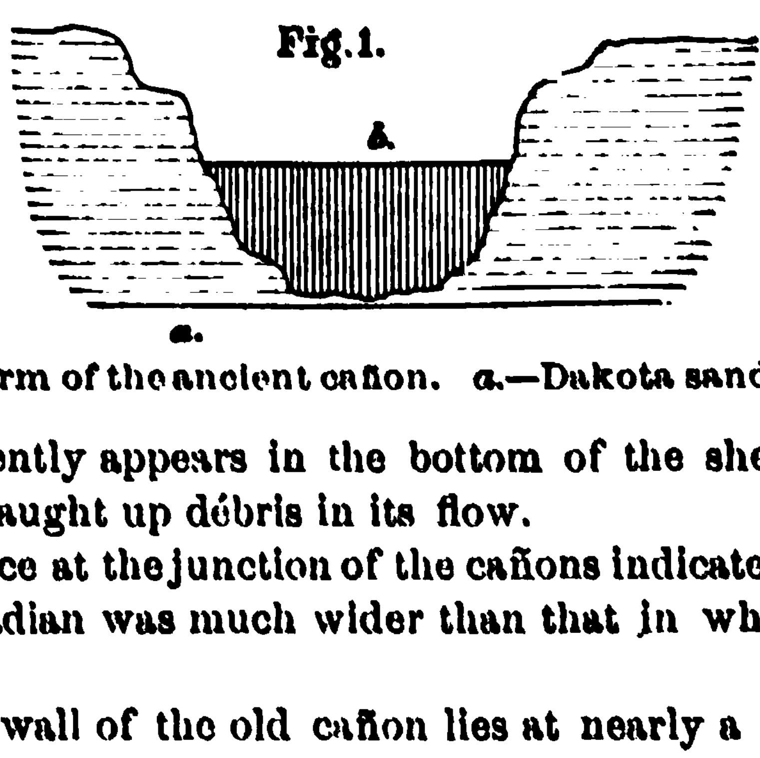


FIG. 1.—Showing form of the ancient cañon. *a.*—Dakota sandstone. *b.*—Basalt.

A breccia frequently appears in the bottom of the sheet, as though the molten rock had caught up débris in its flow.

The basalt terrace at the junction of the cañons indicates that the ancient cañon of the Canadian was much wider than that in which the river now flows.

The south-west wall of the old cañon lies at nearly a mile further from the river than does the present wall, which is capped by the sheet of basalt. It is very evident that before the basalt outpouring occurred the cañons had been digged down at their junction to 860 feet below the present level of the plain, and that the depth was reduced to 470 feet by the influx. But since the streams regained their channel-ways, material to the depth of 620 feet has been removed by corrasion; so that the vertical cutting since the flow ceased is very nearly equal to that done before the flow began. This cutting is wholly the result of corrasion, the wear of the streams upon their beds.

The enormous erosion on the plains and in the tributary cañons must have antedated the Turkey Mountain eruption. The basalt rests on the Dakota sandstone between the crater and the Mora cañon ; it has flowed into the tributary cañons, where it still remains ; the stream is almost wholly continuous across the plain ; the surface of the sheet is scarcely scarred in the side cañons ; while on the terraces of the Mora cañon and on the broad terrace between that and the Canadian cañon, the surface is as regular as though the flow had occurred less than 100 years ago. Such facts make it sufficiently clear that since the Turkey Mountain eruption, the rainfall has been comparatively insignificant. But this season of dryness must have been preceded by one of much greater rainfall, unless, indeed, we conceive that the erosion had been continuing for an indefinite period. But a moment's consideration will show that such a continuance is impossible ; remnants of the Colorado shales remain on the plains as mesas nearly 1000 feet high, which have been protected from erosion by a thick plate of basalt. This plate, which covers the Canadian hills east from the Turkey mountains and is an outlier of a vast basaltic area, marks the occurrence of a previous outpouring, not earlier than the beginning of the Pliocene. The enormous erosion, then, must have been performed during the interval between the eruptions, which, in a geological sense, could not have been very long. There seems, therefore, no room for doubting that a great climatal change passed over this region ; that during the interval between the eruptions the rainfall was great, sufficing for the removal of the thick Colorado group and the digging out of the many imposing arroyos or side-cañons, but that since the later Pliocene the region has been arid, the corrasion of the cañons having been done by water drained from the mountains.

But the new cañons do not coincide with the old ones. A small bit of basalt caps a hill in the Canadian cañon, at somewhat more than 2 miles above the mouth of Mora river ; within a short distance lower, the cañon bends westward, and the thick bed of basalt is well exposed, covering a terrace on the south wall ; soon the gorge curves southward and becomes very narrow as it passes through the basalt, which caps both walls, its base being nearly 200 feet above the stream. But within one-fourth of a mile, a slight bend eastward carries the cañon beyond the basalt, which now lies only on the western wall and covers a bench, stretching thence to the cañon of Mora river. A fragment of basalt remains in the former cañon on an isolated hill almost immediately below the mouth of Mora.

The present cañon of Mora river has the basalt altogether on its northeasterly side for a distance of nearly a mile and a half, and a fragment of the old westerly wall still remains as an irregular conical hill, rising above the basalt terrace. At a little way above this, the basalt has been wholly eroded from both sides of the cañon, excepting only an insignificant and badly broken patch on the south side; but immediately above this, the gorge becomes close, and the basalt is shown on both sides.

It is evident, then, that the cañons have been re-eroded partly along the original line or through the basalt, and partly alongside of the ancient

chasms, the basalt appearing sometimes on one side, sometimes on the other, and occasionally on both sides. One may easily determine whether or not the cañon is wholly beyond the limits of the ancient gorge, since if it be, the wall is sheer to the top; whereas, if the course be along the old channel-way, and the absence of the basalt be due to erosion, the bench previously covered by the lava is still distinct. The cross sections exhibit the features very satisfactorily; thus in passing from one cañon to the other at a little way above the junction, one would find the condition shown in Fig. 2.

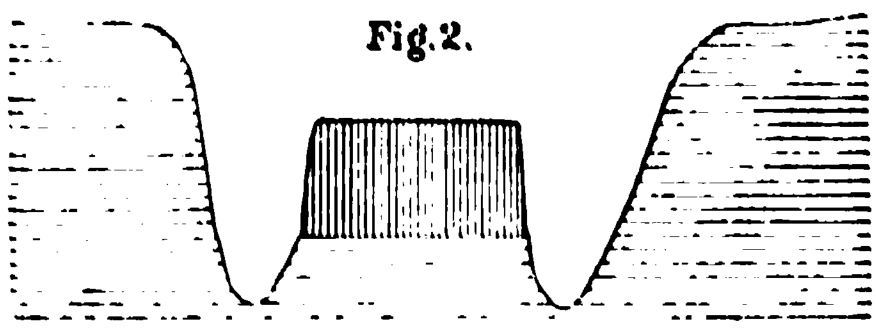


FIG. 2.—Section across cañons of Canadian and Mora rivers near their junction.

The basalt covers the level bench between the two cañons, while the higher wall of each is composed from top to bottom of the Dakota rocks. But at a mile and a half further up the streams the structure is as shown in Fig. 3 where the basalt appears on both sides of each cañon. Here both

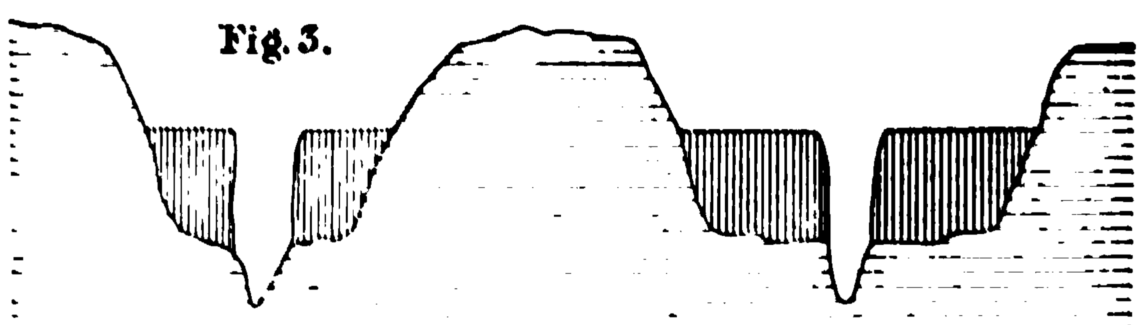


FIG. 3.—Section across cañons of Canadian and Mora rivers, two miles above their junction.

streams have cut their way through the basalt, whereas in the other, both cañons are outside of the sheet.

This new channel-way has been digged out of rocks of unequal hardness, and the corrasion seems to have gone on with equal rapidity everywhere. The gorge is as deep where the basalt plate appears in both walls as it is where the basalt is on one side or wholly away from the cañon. The only observable difference is that, where cut through the basalt, the cañon is very narrow, and the cutting has been confined to the immediate channel-way; whereas, the gorge is wide and shows a "bottom" where it has been worn in the sedimentary rocks only. The Canadian and the Mora are exceedingly rapid and very imperfectly loaded. Their corrasive power is far greater, therefore, than might be supposed, if their volume alone were considered.

Notes on the Geology of Wise, Lee and Scott Counties, Virginia. By John J. Stevenson, Professor of Geology in the University of the City of New York. (With three wood cuts.)

(*Read before the American Philosophical Society, August 20, 1880.*)

During the winter of 1880, General J. D. Imboden discovered valuable coal beds near the Big Stone gap in Wise county, Virginia, at about sixty miles from the Tennessee line. The property soon passed into the hands of Northern capitalists, for whom I have investigated its economic value. The facts obtained may be of interest, as the only attainable information respecting Southwest Virginia is contained in the brief memoirs by Prof. J. P. Lesley* and in Prof. Safford's Geology of Tennessee. I am under very especial obligation to General Imboden, who, previous to my arrival, had studied the general geology with much care.

The area to be described in this paper includes those portions of Wise, Lee and Scott counties which are drained by the forks of Powell river and by the North Fork of Clinch river. Its north-western boundary is Black mountain, a ridge of the Cumberlands, which here forms the line between Virginia and Kentucky. At some distance from the Tennessee line, Stone mountain separates itself from that mountain and follows a N. 56° E. trend for about fifty miles to the Little Stone gap, where it unites with Powell mountain, which comes from the west of south-west. No examination was made beyond that gap, but, according to the map accompanying Prof. Lesley's memoir of 1872, the two mountains separate again and are distinct for several miles further toward the east. Wallen's ridge begins midway in the valley between Stone and Powell mountain at three or four miles south of west from Little Stone gap, and continues rudely parallel with Stone mountain to somewhat more than a mile beyond the Big Stone gap. There it is divided by a narrow valley into Wallen's ridge and Poor Valley ridge, which continue beyond the State line into Tennessee.

Two forks of Powell river known as Pigeon and Roaring, rise on the southern slope of Black mountain and unite at the head of the Big Stone gap. The South Fork rises in the valley between Powell mountain and Wallen's ridge, flows through the eastern extremity of the latter and unites with the river at barely a mile below the Big Stone gap. The North Fork of Clinch river rises in the valley between Wallen's ridge and Powell mountain and breaks through the latter mountain at the North Fork gap, which is about twenty-five miles south-west from the Little Stone gap. Thence it flows eastwardly to Clinch river.

Two lines of section were followed; one beginning on the crest of Stone mountain, at say a mile west from the Little Stone gap and crossing the valley to the crest of Powell mountain; the other beginning at Black mountain and continuing southward through the Big Stone gap, across both Poor Valley and Wallen's ridges to the south-eastern side of Powell

* Proceedings of this Society, 1862 and 1872.

mountain. Unfortunately, there was no opportunity to make accurate measurements of horizontal distances and the scale of the cross-sections is probably somewhat distorted. In neither case was Powell mountain crossed along the line of section and the details respecting its southern side are taken from features observed in the North Fork gap.

The western section is shown in Fig. 1.

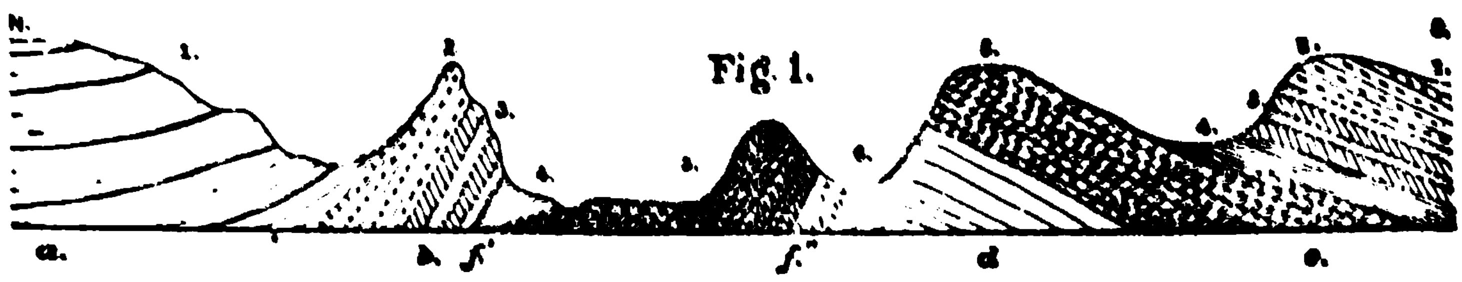


FIG. 1.—Cross-section from crest of Black Mountain to south-eastern side of Powell Mountain. *a*, Black Mountain; *b*, Stone Mountain; *c*, Poor Valley Ridge; *d*, Wallen's Ridge; *e*, Powell Mountain; *f'*, Stone Mountain fault; *f''*, fault of Poor Valley Ridge. 1, Coal Measures; 2, Conglomerate; 3, Lower Carboniferous; 4, Devonian; 5, Upper Silurian; 6, Lower Silurian.

Beginning at Black mountain, one finds himself amid the Coal Measures; going southward, he sees a slow but steady increase in dip until, as he approaches the Big Stone gap, it becomes nearly two degrees. But there the increase is very rapid, so that at the head of the gap the Seral conglomerate is dipping north-north-west at 80 degrees. The Lower Carboniferous limestone forms a bold cliff on both sides near the mouth of the gap and dips in the same direction at 70 degrees. Here a fault occurs, and one comes at once to *black shales* of unknown thickness, dipping in like direction at barely 20 degrees. Below these are the Lower Helderberg rocks, well exposed and of considerable thickness. On the south side of the Poor valley, and the northern slope of Poor Valley ridge, are the Clinton rocks with the fossiliferous ores, which continue to the head of Cedar gap, through which one comes to Turkey cove, separating Poor Valley ridge from Wallen's ridge. At the head of this gap, one crosses another fault and soon comes to the Trenton limestone, which is pressed into many short, close curves, but finally takes an almost due east dip on the northerly face of Wallen's ridge. The Medina sandstone is shown on the crest of that ridge, while the Clinton and Lower Helderberg rocks are well exposed in the valley between Wallen's ridge and Powell mountain. The black shales appear in the side of the latter ridge, with the Lower Carboniferous limestone higher up and the Conglomerate at the crest. On the opposite side of the mountain Hunter's valley is reached and there one finds the Coal Measures.

The other section, extending from the crest of Stone mountain to that of Powell mountain, is not more than seven miles distant from the other section, but it shows a great difference in the structure.

Here, beginning at Stone mountain, one finds as before the Coal Measures, Conglomerate and Lower Carboniferous forming that mountain ; in the valley, the black shales are shown at the base of each ridge, while the Lower Helderberg rocks occupy the center of the valley, where they describe an anticlinal, exceedingly sharp near the axis, but showing much gentler dips on each side as Stone and Powell mountains are approached.

Fig. 2.

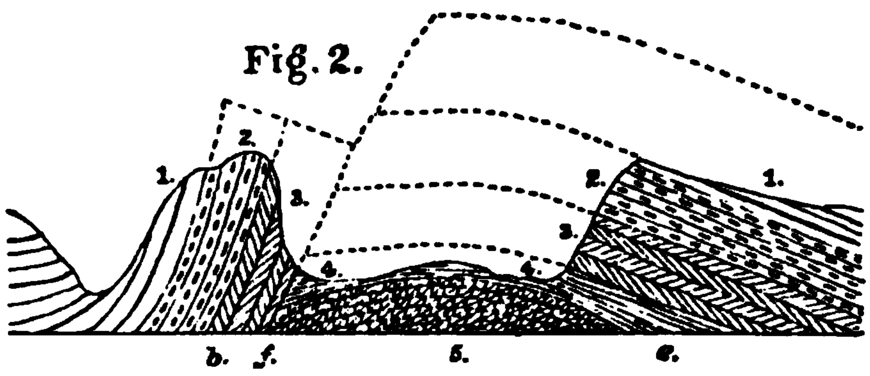


FIG. 2.—Cross-section from crest of Stone Mountain to that of Powell Mountain. The dotted lines show extent of material removed by erosion.

It is altogether probable from the best information attainable that a fault, rudely parallel to Stone mountain, exists in Kentucky at but a little way from the State line.

The general structure of the region between Black mountain and the Clinch river will be discussed in another part of this paper.

The Coal area between Black mountain and Stone mountain is extensive, but that within Hunter's valley is insignificant.

The Coal Area Drained by Pigeon and Roaring Forks of Powell River.

The Coal area, which begins immediately behind Stone mountain and extends thence to beyond the crest of Black mountain, is evidently the same with the Kentucky series, so well exposed in Harlan and Letcher counties of that State. The upper part of the Seral (Pottsville) Conglomerate forms the northern face of Stone mountain and the Coal Measures come in at the foot of the ridge, where the dip is very nearly vertical.

A series of barometrical observations shows that the series rises eastward from the mouth of Callahan creek, about a mile above the head of Big Stone gap. This rise of the whole region is rapid and is sufficient, if continuous, to carry most of the beds into the air within a few miles ; so that only the lowest beds could be found at but a little way beyond the Little Stone gap.

For the most part, this region is still a wilderness, and exposures rarely occur except in the stream beds, which, owing to rapid fall, are usually clear. Several of the tributaries to Roaring fork were followed almost to their heads in the south-east side of Black mountain ; and this general section was compiled from the measurements made on them.

1.	Not examined in detail	500′
2.	*Coal bed*	0′ 4″
3.	Sandstone	30′
4.	*Coal bed*	1′ 5″
5.	Sandstone and shale	115′
6.	*Coal bed*	0′ 6″
7.	Sandstone	70′
8.	*Coal bed*	2′
9.	Fireclay with stigmaria	2′
10.	Sandstone	12′
11.	*Coal bed*	1′
12.	Sandstone	70′
13.	Shale	20′
14.	*Coal bed*	0′ 4″
15.	Sandstone	26′
16.	Shale	4′
17.	*Coal bed*	0′ 10″
18.	Ill exposed, mostly sandstone	65′
19.	*Coal bed*	7′ 3″
20.	Sandstone	35′
21.	*Coal bed*	3′ 6″
22.	Sandstone	60′
23.	*Coal bed*	3′ 6″
24.	Ill exposed, mostly sandstone	120′
25.	*Coal bed*	Blossom.
26.	Sandstone	70′
27.	*Coal bed*	1′
28.	Shale and sandstone	22′
29.	*Coal bed*..........extreme thickness	15′
30.	Sandstone	45′
31.	Shale..........from 0′ to	5′
32.	*Coal bed*..........extreme thickness	8′
33.	Shale	6′
34.	Sandstone	35′
35.	*Carbonaceous* shale	0′ 4″
36.	Sandstone	70′
37.	Ill exposed, mostly sandstone	65′
38.	Sandstone	30′
39.	*Coal bed*	2′
40.	Shale	10′
41.	Sandstone	40′
42.	*Coal bed*	2′
43.	Shale and sandstone	100′ ?
44.	*Coal bed* and shale	5′
45.	Interval to conglomerate..........estimated at	80′
	Total	1751′

Exposures become poor near the top of Black mountain along all of the streams which were followed, and the upper part of the section was not made out. Sandstones and shales seem to be continuous for 200 feet above the highest *coal bed* seen in place ; but there is certainly one *coal bed* within the undetermined interval beyond, as fragments of *cannel* were found abundantly at fully 200 feet up in that space. No limestone occurs in beds, but some nodular limestone was discovered within six feet above No. 17; and fragments of an exceedingly impure limestone, with a cone-in-cone structure in its more argillaceous portions, were found above No. 6.

Calahan creek is the main tributary of Roaring fork ; its larger branches are known as Kelly's, Church House and Preacher runs. Looney creek is an important stream entering Roaring fork near its junction with Pigeon fork. On all of these, as well as on Pigeon fork, exposures were found, but the upper part of the section was obtained satisfactorily only on Preacher run.

The study was not sufficiently prolonged to admit of classifying the beds or of determining their relations to the groups recognized in Pennsylvania. There seems, however, to be a natural line of division about midway in the section : for, above the *coal bed,* No. 19, to within 250 feet of the top of the column, no thick *coal bed* occurs. It may be that the lower portion, for about 833 feet, is equivalent to the Lower Coal Measures of Pennsylvania as represented on the Great Kanawha river of West Virginia, and that the upper portion is equivalent to the Lower Barren Group of Pennsylvania. I have noticed in another place* the extraordinary thickening of the Lower Coal Measures southward ; how this group, rarely more than 350 feet thick in Pennsylvania increases southward from the line of the Baltimore and Ohio railroad in West Virginia, until in Randolph county it is 700 or 800 feet thick. The increase continues southward and on the Great Kanawha the same group is upwards of 1200 feet thick.

On the Kanawha, the top of this group is distinct ; for the "*flint ledge,*" occurring in close proximity to the Mahoning sandstone, is a well-marked horizon. But on the headwaters of Powell river the "*flint ledge*" seems to be wanting, and no traces of it could be found. The division here, therefore, is arbitrary and a final determination of the matter must be postponed until opportunity has been had for less hurried investigation. It is quite possible that the full thickness of the group is not given in the section, as the lower intervals were merely estimated.

If the top of the Kanawha series be at *coal bed,* No. 19, some representative of the Upper Productive Coal Series of Pennsylvania may be sought near the crest of Black mountain ; for while the Lower Productive Coal Series shows the remarkable increase southward, the Lower Barren Group shows no such increase. Its extremes are 500 and 700 feet, both of which may be found within the limits of a single township in different parts of Pennsylvania. No system of variation in this group has been discovered,

* Proceedings of this Society for 1875. Notes on Geology of West Virginia, No. II.

possibly because the group possesses comparatively little economic importance, so that it has received less study than has been given to the other coal groups of Pennsylvania. But the close investigation, which Mr. W. G. Platt has been making of this group for the Pennsylvania Geological Survey may remove the obscurity.

The *coal bed*, No. 19, as exposed on Preacher run, has the following structure :

1. *Cannel*	2′	7′ 3″
2. Shale	0′ 4″	
3. Slaty *coal*	0′ 4″	
4. Shale	0′ 5″	
5. *Coal*	0′ 5″	
6. Shale	0′ 4″	
7. *Coal*	3′ 5″	

The *cannel* is compact and much like that which is obtained in Armstrong county of Pennsylvania. It contains many fragments of sandstone, whose presence seems to indicate that the material of which the *coal* was made was pulpy, not like that which accumulated to form the ordinary beds. No distortion of the *coal* appears, such as was seen about the large fragment which I discovered* in the *Sewickley coal bed* in Fayette county, Pennsylvania. The fragments are small and angular, and doubtless they were attached to some tree, which had been uprooted during a freshet. The same bed was seen on Calahan creek, where it shows :

Coal	0′ 5″	19′
Shale	10′	
Coal	1′ 2″	
Shale	7′	
Coal	0′ 5″	

and is therefore worthless.

Coal bed, No. 21, is exposed on Preacher run and Calahan creek, and fragments of it were seen on Looney creek, though the bed itself was not found. On Preacher run it is finely shown at two miles from the mouth of the stream, where it is from 3′ 6″ to 3′ thick and yields a *splint coal* of remarkably fine quality. The roof is a hard, compact sandstone and the *coal* shows but insignificant partings. An analysis of this coal by Mr. A. S. McCreath, of the Penn. Geol. Surv., gave

Water at 225°	0.880
Volatile matter	37.580
Fixed carbon	58.059
Sulphur	0.406
Ash	3.075

* Second Geol. Surv. of Penn. Rep. on Fayette and Westmoreland counties. [KK.] p. 216.

This *coal* is well adapted for use in the furnace, as it has an extremely low percentage of sulphur and ash. The analysis just given may be compared with one of the *Sharon* or *Block coal*, which is used extensively in the iron works of eastern Ohio. This is also by Mr. McCreath, and is given in Report MM of the 2d Geol. Surv. of Penn., p. 99.

Water at 225°	3.790
Volatile matter	35.300
Fixed carbon	53.875
Sulphur	0.675
Ash	6.360

Coal bed, No. 28, is very similar to the last. It is 3′ 6″ thick on Preacher run, but is 4′ 6″ on Looney creek. It is persistent throughout the area examined and holds its thickness well.

Only the blossom of No. 25 was seen. No. 27 is persistent but always thin. Lying as it does between two plates of hard sandstone, it is often useful in indicating the place of the large bed below.

Coal bed, No. 29, is exceedingly variable, though altogether persistent. It has been opened on Pigeon fork at probably two-thirds of a mile above the mouth of the stream, where it shows:

Coal	6′ 10″	
Shale	0′ 10″	
Coal	2′ 5″	14′ 10″
Shale, averaging	0′ 3″	
Coal	4′ 6″	

A similar structure was seen on the first branch of Pigeon fork, and at both localities the upper division is so slaty as to be apparently of little value. The middle division is soft, has a prismatic structure and cokes well; the lower division is, for the most part, a splint coal of very fair quality, though it is somewhat inclined to be slaty near the base. On Looney creek, only the middle and lower divisions remain, the upper division having been removed by a horseback of clay. The character of the remaining divisions is the same as on Pigeon fork, but the *coal* is more liked and that from the middle division is carried to long distances for use by blacksmiths. Eastward from Looney creek, the bed is exceedingly variable; on Preacher run it is but two inches thick, on Kelly's run it is insignificant, and on Church House run it seems to be not more than one foot But at an exposure near Roaring fork, at about two miles above the head of Big Stone gap, the bed is evidently very thick, though the exposure is too indefinite to admit of definite measurement. At all localities the lower parting shows many impressions of *Sigillaria* and *Syringodendron*.

As the middle division of this bed seemed to be a good coking *coal*, a sample was forwarded to Mr. McCreath for analysis. Its composition is:

Water at 225°	1.610
Volatile matter	38.850
Fixed carbon	57.879
Sulphur	0.771
Ash	0.890

which shows it to be a gas coal of superior quality. The coke, in point of ash, cannot be excelled.

Coal bed, No. 32, is the most important and least variable bed of the series and it is likely to prove of great economical importance, as it will afford *coke* for working the vast deposits of iron ore which exist along the line of the Atlantic, Mississippi and Ohio railroad and in Northwestern North Carolina. It was seen on all of the streams except Looney and Calahan creeks, the place of the bed being concealed on those streams where the water runs over it. A line of springs marks its outcrop on Pigeon fork and the *coal* is exposed on the first branch of that fork. An imperfect opening on Church House run shows:

Coal	3′ 10″	7′ 9″
Shale	0′ 5″	
Coal	3′ 6″	

The top part of the bed for eleven inches is very hard, a true *splint*, which is an advantage, as the roof is not always secure; but the remainder of the upper bench is very soft and much of it has a prismatic structure. The lower bench is somewhat less soft, but is very tender. The *coal* taken out at this opening cokes well. An exposure near the mouth of Preacher run shows:

Coal	2′ 8″	6′ 11″
Parting	—	
Coal	1′	
Shale	0′ 3″	
Coal	3′	

At a mile further up the run, the bed has the same structure, but is only 6′ 9″ thick. The coke made at the latter opening is very hard, porous and silvery. On Kelly's run the bed is somewhat thicker and shows:

Coal	4′ 5″	8′ 5″
Shale	0′ 3″	
Coal	3′ 9″	

But the character of the exposure is not such as to indicate the quality of the *coal*. The same bed is shown on a little branch of Roaring fork, where it is not far from eight feet thick. *Sigillaria* and *Syringodendron* impressions are numerous in the shale parting.

To determine the quality of the *coal*, samples were taken from all the benches except the hard *splint coal* on top. These yielded the following on analysis by Mr. McCreath:

Water at 225°	1.380
Volatile matter	35.920
Fixed carbon	60.591
Sulphur	0.594
Ash	1.515

It is therefore a *coking coal* of marvelous excellence. The coke will contain less than three per cent. of ash and barely a half per cent. of sulphur. This coke is far superior to that from the Connellsville region, and better than that from the Oxmoor Works in the Cahawba basin of Alabama. It is decidedly better than the coke from the New River region of West Virginia.

No. 39 is a persistent though valueless bed. It has been mined near the mouth of Church House run, where it is two feet thick and yields an inferior *splint coal*, which is very rich in sulphur. Its blossom appears in the bluff above the road alongside of Roaring fork for nearly two miles above the head of Big Stone gap.

The interval, No. 37, could not be made out. The whole face of the coal-area fronting on Roaring and Pigeon forks is injured by extensive slides, which conceal this interval everywhere.

No. 42 was seen above the mouth of Calahan creek in the bed of Roaring fork, and in the bed of Pigeon fork at probably a mile above its mouth. The *coal* is said to be very good, a condition due no doubt to the removal of its sulphur by the water.

The remainder of the section was not measured. The lower members rise quickly toward Stone mountain and the rate of dip varies so greatly that thicknesses could not be determined during a mere reconnaissance.

The Seral (Pottsville) Conglomerate.

The Conglomerate forms the northern side of Stone mountain and its cliffs dip N. N. W. at between 70 and 80 degrees. The intervals between these cliffs must be occupied by shales or very soft sandstones as they afford no exposures. The group as shown in the Big Stone gap is not less than 1000 feet thick, but, owing to the dense forest, it was impossible either to gain a general section or to get the detailed structure of any portion. It was not determined, therefore, whether or not the Quinnemont series of *coal* beds is present here. This cannot be ascertained until the foliage has fallen.

The sandstones in the cliffs vary from fine-grained to coarse conglomerate, the latter containing quartz pebbles as large as a pigeon's egg. The highest bed is a moderately fine-grained rock and is well shown at the head of the gap, where it dips at 80 degrees. This is known as the "Bee-rock," as the laurel blossoms covering it are the resort of immense numbers of bees during the early summer. It shows many rude impressions of *Sigillaria* and extends along the north face of Stone mountain to beyond the Little Stone gap.

The Lower Carboniferous.

Like the Conglomerate, these rocks are found only in the mountains, and details respecting their thickness and composition cannot be ascertained until after the foliage has disappeared. They are shown along the south face of Stone mountain from Little Stone gap westward to the Tennessee line, and on the northerly face of Powell mountain from that gap to the North Fork gap, where the Carboniferous series ends. The Umbral Limestone follows the left hand side of the gap until within a short distance of Clinch river.

No detailed exposure of the interval between the Conglomerate and the Umbral Limestone was discovered, but it is not far from 500 feet thick, and appears to be filled chiefly with red shale, of which a few short exposures were seen.

The limestone appears as a cliff along the southern face of Stone mountain and is well shown on both sides of Big Stone gap, where it dips N. N. W. at 70 degrees, and, as nearly as can be estimated, is between 250 and 300 feet thick. The turnpike is cut through it at Little Stone gap. Thence, along Powell mountain, it is seen as a broad band to the North Fork gap, where its outcrop bends eastward and follows the left hand side of the gap almost to Clinch river. For the most part, this rock is compact and fine grained, but some of the beds are granular. Chert, in nodules as large as an ordinary orange, is plentiful in one layer. Fossils occur throughout the mass, but the specimens are not silicified and the species are not readily identifiable. *Productus cora* and *Zaphrentis spinosa* were obtained near the mouth of Big Stone gap. Many layers of this limestone are very pure and yield a lime of superior quality. The rock is cavernous and the large caves in Powell mountain afforded a supply of saltpetre to the Confederates during the late war.

Whether or not rocks of *Vespertine* age have been brought up along the face of Stone mountain was not ascertained; but the position of the limestone at a few miles west from the Big Stone gap renders probable that no representative of that group has been brought up. On the northerly face of Powell mountain, however, the succession is unbroken and the Vespertine rocks are undoubtedly present there, although they are concealed. A *coal* bed exists in the North Fork gap at a considerable distance below the limestone and therefore belongs to this group. *Coal* from it was used at a catalan forge in the gap.

The Devonian Rocks.

The immense Devonian series of New York and Pennsylvania is insignificant here and is represented only by *black shales*, which are exposed along the foot of both Stone and Powell mountains. These shales cross the valley near Little Stone gap, where their dip is abrupt near the central line of the valley, but becomes gentler toward each mountain. They are the equivalent of Prof. Safford's "*Black shales.*" Their thickness was not determined accurately, but it cannot exceed 500 feet. No fossils were found in them.

The Upper Silurian Rocks.

The Lower Helderberg, the Clinton and the Medina were recognized.

The Lower Helderberg.—The rocks of this group are exposed in the Poor valley; on the eastern end of Wallen's ridge; in the valley between Wallen's ridge and Powell mountain; in the North Fork gap, and on the south-eastern slope of Powell mountain beyond that gap. The exposures are very fair and a complete section could be obtained without much difficulty.

The estimated thickness is not far from 250 feet. For 70 feet from the bottom the series consists of limestones in beds of from three to five feet, separated by shales in somewhat thicker layers. The lower limestones are silicious, but, toward the top, the beds are purer and one of them, black, fetid and four feet thick, contains abundance of *Leperditia*. Overlying this is a succession of coarse-grained calcareous sandstones, shales and silicious limestones, not well exposed along the line followed in the attempt to secure a section. The lower calcareous sandstone is shown in a line of low hills near Big Stone gap, and also on the turnpike within a mile of Cedar gap; the larger of the silicious limestones is shown near the pike opposite the gap, and also on the north side of Powell river at barely a mile below the gap. It is very light in color and has a cherty look. Immediately above it is a coarse reddish-gray sandstone, closely resembling the Oriskany sandstone of New York.

The lower sandstone is well shown on the pike, where it seems to be made up almost wholly of casts of *Orthis oblata*, *Rhynchonella ventricosa*, and undetermined *Meristella*.

The silicious limestone yielded *Crinoid stems*, abundant; *Aspidocrinus scutelliformis*; *Chætetes*; *Favosites*; *Atrypa reticularis*; *Strophomena rhomboidalis*; *Strophodonta*; *Spirifer cyclopterus*; *Meristella*; *Rhynchonella nucleolata*; *Orthis oblata*; and other forms which were not recognized.

The immediately overlying sandstone has a broad *Meristella*; *Spirifer perlamellosa*; *Favosites*; *Caninia helderbergiæ*; the last two in great abundance.

At some distance up the valley, say four miles above the Big Stone gap, on property belonging to Mr. Spencer, the upper silicious limestone becomes impregnated with brown hematite. Usually only the joints have been filled, but occasionally for considerable distances the rock has been replaced by limonite. The ore is too silicious to be of any value. The fossils are distinct. Along the valley between Wallen's ridge and Powell mountain, the Lower Helderberg rocks can be followed easily; the silicious limestone and the lower calcareous sandstone have been replaced to a greater or less extent by brown hematite. The outcrop of the lower ore follows the hillside above the road for miles, while the upper bed follows the creek-bottom almost to the head of Wildcat creek. Much of the ore at the upper horizon is exceedingly poor, but there are some pockets of decidedly good material. The fossils are the same with those seen at the same horizon in the Poor

valley. The lower horizon makes a fine showing along the hillside and the fragments that have fallen to the road are often of such excellent quality that a passing observer might be led to suppose that the deposit is of uniformly good quality. Unfortunately, the ore here, as at every other locality, is variable. Much of it is merely the sandstone permeated with limonite, sometimes half its bulk being ore. There are, however, numerous pockets, some of them very large, which contain ore of marked excellence, as appears from the following analysis by Mr. McCreath :

Metallic iron	52.550
Sulphur	0.037
Phosphorus	0.051
Insoluble residue	7.840

Thus containing only .097 of phosphorus in 100 parts of iron.

This hematite occurs on the south-east face of Powell mountain beyond the North Fork gap, but no examination was made there to determine its extent or quality.

The Clinton Group.—In the low hills alongside of the turnpike and opposite the Big Stone gap, the following succession of the rocks underlying the Lower Helderberg was made out.

1. Mostly concealed, with here and there an insignificant exposure of sandstone ; probably contains some pure limestone, as fragments were seen on the surface. Estimated at	250′
2. Red to yellow fissile shales, with thin layers of fine grit. Dip almost vertical	60′
3. Imperfectly exposed ; has occasional layers of reddish grit	35′
4 Fine grained calcareous grit, passing downward into silicious limestone. The upper half contains little calcareous matter and is very hard ; but toward the base, the rock becomes comparatively good limestone. No fossils were seen. The dip at the top is 70 degrees, but decreases downward, becoming 56 degrees at the base	60′
5. A concealed interval	75′
6 Deep red flaggy sandstone, very fine-grained and exceedingly hard ; dip is 80 degrees toward N. N. W. This rock contains many *Fucoids*, but no other fossils were seen except a weathered cast of *Orthoceras*	8′
7. Shales, red to yellow, brittle, with thin layers of hard shale containing *Fucoids*. The dip is indistinct	50′
8. Silicious limestone, not unlike that seen in the Lower Helderberg	5′

Below this, the succession is very indistinct along the three lines on which a section was attempted. The cherty limestone contains many fossils, but they are not well preserved, and the species are indistinct.

Below the rocks of the section is a series of shales and sandstones, in which are found the fossil ores of this group. No estimate of the whole thickness was made.

The Clinton rocks are well shown on the south side of Poor valley, and from the northern face of Poor Valley ridge. They occur on the north side of Wallen's ridge above the mouth of South Fork of Powell river, and are well exposed along the southerly face of that ridge for several miles. They appear also on the south-easterly slope of Powell mountain beyond the North Fork gap. At all of these localities the fossil ores are found.

Three beds of ore were seen in the Poor Valley region. The highest belongs probably within the concealed interval No. 7 of the section. It shows itself in the bank of Powell river at about half a mile from the gap with a thickness of from 5 to 8 inches, and a dip of 56 degrees toward N. 25° W. It is included in greenish shales, which are rich in *Fucoids*.

The second bed crops out in the "bottom" at say half a mile further down the river. It is important, and has the following structure:

Hard ore	4′ 8″
Soft ore	2′ 6″

The upper layer has very fair ore in its lower 20 inches, which could be used in a furnace. It is harder than the tender fossiliferous ore below, and contains fewer fossils, but it is much less hard than the other part of this layer. The strike is N. 40° E., and the dip is 45 degrees. The bed was followed for a considerable distance, but no material variation in thickness was observed.

A third bed was seen near Cedar gap, but the exposure there is somewhat indefinite. The hard ore predominates, and is far from being good.

The last two beds occur on Wallen's ridge at but a little way above the mouth of South Fork of Powell river.

Two beds only were seen on the south face of Wallen's ridge along Wildcat creek, a tributary to the South fork. One of these is 25 inches thick, and dips at 10 degrees in an almost east direction. The other bed shows:

Soft ore	2′
Hard ore	2′ 2″

overlying one foot of ferruginous shale, which rests on a flaggy sandstone. The upper part of the soft ore is almost granular, and can be removed with a shovel, but it is inferior to the other part, and contains many small rounded quartz pebbles. The hard ore shows very few fossils. The dip is 11 degrees and almost due east.

The ordinary ore of this region is very good, as appears from the following analysis by Mr. McCreath, of a specimen from Wallen's ridge:

Metallic iron	52.600
Sulphur	0.018
Phosphorus	0.116
Insoluble residue	18.140

there being but .220 of phosphorus in 100 parts of iron.

The very soft or granular ore was analyzed. It has the same character as the last, except that, owing to the presence of the quartz pebbles, the insoluble residue is very great. The proportion of phosphorus is .228 in 100 parts of iron.

Three beds were seen in the area along the south-east slope of Powell mountain beyond the North Fork gap. The highest one is thin and contains only silicious ore. The second bed shows:

Ore	1′
Shale	1′
Limestone and Ore	0′ 5″
Shale	0′ 4″
Ore	0′ 5″
Shale	0′ 4″
Ore	1′

At 50 feet below this, the interval being filled with sandstone, another bed was seen showing:

Very soft ore	1′ 8″
Hard ore	1′ 6″

The ore in both of these beds is leaner than that seen in Poor valley and on Wallen's ridge, but it can be mined very cheaply. These Powell mountain ores show the fossils much more distinctly than do those in the other localities and the forms are larger. *Leptocœlia hemispherica, Streptorhynchus subplana* and the pygidium of a *Calymene* occur abundantly.

The Medina Sandstone.—This was seen only on the crest of Wallen's ridge near the head of the valley separating that ridge from Poor Valley ridge. It is a moderately coarse, light gray sandstone, evidently more than 800 feet thick, and so far as observed contains no fossils.

The Lower Silurian Rocks.

No rocks of this age appear in the Poor valley within at least 15 miles west from the Big Stone gap; nor are they exposed between Wallen's ridge and Powell mountain between North Fork and Little Stone gap; nor do they come to the surface along the south-east slope of Powell mountain beyond that gap. But they are well exposed on the northerly face of Wallen's ridge and in Wallen's valley, which separates that ridge from Powell mountain beyond the North Fork gap.

Limestone is the prevailing rock and there is little reason to believe that even the base of the limestone of II is reached at any exposure within the area examined. With the limestone, shale is interstratified, which is sometimes fissile but often compact and not laminated. One cannot fail to note

the deep red color of the débris covering the outcrop of the limestone, which so often resembles the decomposed outcrop of a limonite bed.

In Wallen's ridge the limestone has an almost east dip, but in the valley between that ridge and Poor Valley ridge it is pressed into very close abrupt folds, in which the dips sometimes exceed 60 degrees. In these folds, too, the dip is twisted, so that instead of being east and west, it becomes first N. W. and S. E., and then N. N. W. and S. S. E. The lowest member of the series is a mass of reddish to yellow shales, which are so distorted that their thickness could not be determined. These, however, are probably only a part of the limestone series.

Whether or not any shales intervene between the limestone and the Medina sandstone above, was not ascertained, as a concealed interval occupies the space between the two formations. These rocks do not come to the surface again toward the east until near Clinch river, where Stock creek has eroded a tunnel through a hill of the limestone. In the limestone of Wallen's ridge, *Strophomena alternata*, *Leptæna sericea*, *Orthis occidentalis* and other species characteristic of the Trenton limestone occur abundantly.

General Structure of the Region between Black Mountain and Clinch River.

The following diagram, Fig. 3, which is a continuation of Fig. 1, represents the structure of the region between the fault of Poor Valley ridge and Clinch river :

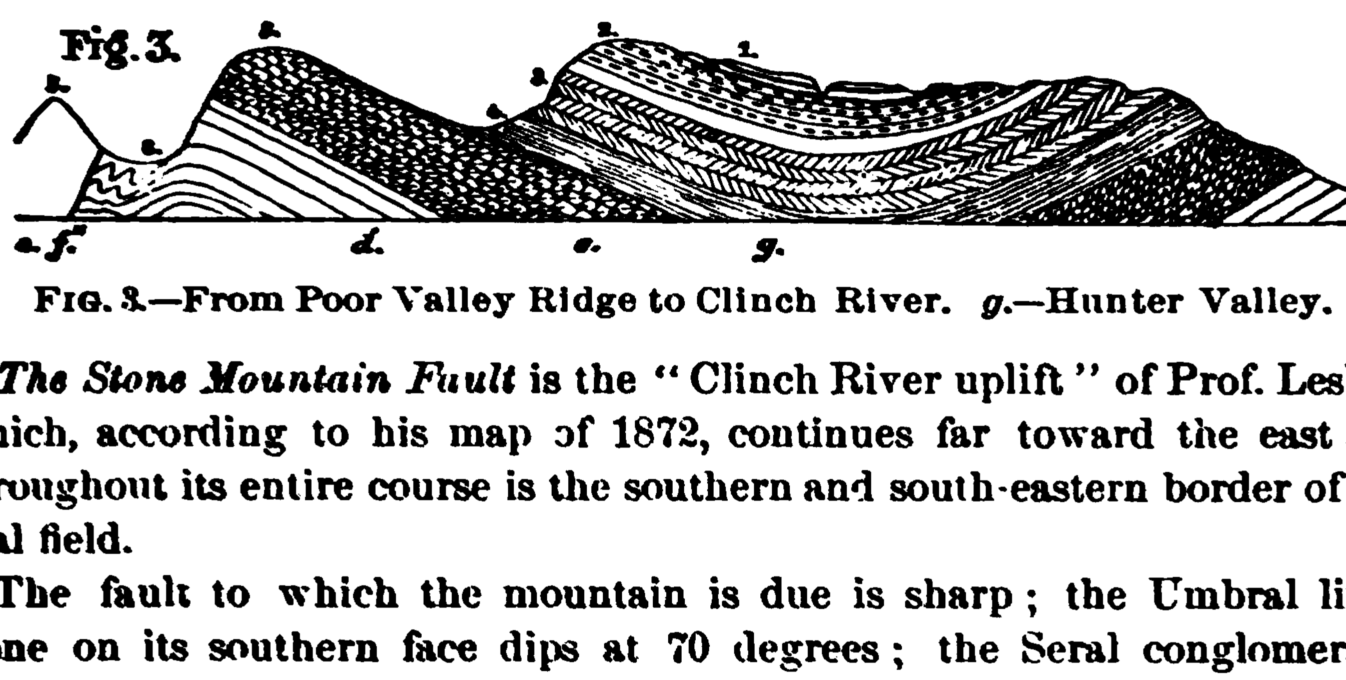


FIG. 3.—From Poor Valley Ridge to Clinch River. *g.*—Hunter Valley.

The Stone Mountain Fault is the "Clinch River uplift" of Prof. Lesley, which, according to his map of 1872, continues far toward the east and throughout its entire course is the southern and south-eastern border of the coal field.

The fault to which the mountain is due is sharp ; the Umbral limestone on its southern face dips at 70 degrees ; the Seral conglomerate, at more than 80 degrees ; but the dip decreases with great rapidity, diminishing from 80 to 2 degrees within a very few rods and soon becoming less than 1 degree. Only the lowest rocks of the coal measures are involved in this abrupt dip and of those the projecting portions have been removed by Pigeon and Roaring forks of Powell river within the area visited.

Looking across the valley from Stone mountain to Powell mountain, one sees at once the relations of the Stone Mountain fault : for the Poor Valley Ridge fault is represented there only by a gentle anticlinal. The conditions are as shown in Fig. 2, where the dotted lines represent portions which have been removed by erosion ; the whole section, as given in the diagram, is pre-

served at the head of the South Fork of Powell river, where the divide between that stream and the West Fork of Stone creek joins the two mountains. The figure exhibits the fact that here there is a cracked anticlinal, with the crack at some distance north from the line of the axis. The succession of the rocks on the south side of the axis is continuous from the Lower Helderberg to the Coal Measures, the latter being present in Hunter valley, on the southerly side of Powell mountain; but on the north side of the axis the succession is broken, and the Black Shales of the Devonian rest against the upturned beds of the Lower Carboniferous. It is evident that during the plication of the rocks the beds gave way, and that the lateral shove was so strong as to push those on one side of the fracture into an almost vertical position, while those on the other side were simply raised or perhaps pushed over on to the upturned edges of some lower rocks, which are not shown at the surface along the line of the fault. It is altogether probable that the rocks now occupying the valley along the southern foot of Stone mountain rest on beds of Vespertine age.

The vertical extent of this fault is less than one might suppose, and doubtless is little more than 6000 feet. The Devonian is represented here only by black shales, which are of inconsiderable thickness when compared with the great mass of Devonian rocks in New York and Pennsylvania. If erosion had not removed so much material along the Powell river and its tributaries, one might have found throughout only the condition indicated by the dotted lines in Fig. 2; and the vertical extent of the fault would have been regarded as altogether insignificant, for the Lower Carboniferous limestone is practically in contact on both sides of the fault in the vicinity of the Little Stone gap.

The Fault of Poor Valley Ridge.—A petty anticlinal exists between Powell and Stone mountain in the valley near the Little Stone gap. Its dips are more abrupt on the northern than they are on the southern side, while at the same time they are much more abrupt near the axial line than they are at a little distance from it. Only the Devonian and Lower Helderberg rocks are brought to the surface in the valley here.

At but a little toward the west a crack appears in this anticlinal and soon develops into the well-marked fault of Poor Valley ridge, which is approximately parallel to the Stone Mountain fault and lies at say three miles S. S. E. from it. Erosion has been actively at work along the southerly side of this fault and has divided Wallen's ridge into Poor valley ridge and Wallen's ridge, the separation first becoming distinct at Cedar gap, somewhat more than a mile below the mouth of the South Fork of Powell river.

As the two faults are approximately parallel, the dips are the same in direction on the northern side of both; but on the southerly side of the Poor Valley Ridge fault, the dips are almost due east, as is well shown at the head of Turkey cove. Entering this valley from the north by way of Cedar gap, one finds the structure represented in Fig. 1. The Clinton rocks on the north side of the fault strike N. 70° E. The Lower Silurian rocks, on the opposite side, which have been shoved into closely compressed

folds, have at first N. N. W. and S. S. E. dips : but within a very short distance the direction changes to N. W. and S. E. ; and the veering toward the east continues until, on the side of Wallen's ridge, the great Trenton limestone dips at N. 80° E., very nearly the same as the strike of the Clinton rocks. Dips of 30 to 60 degrees are common enough on the northern side of the fault, but on the southerly side they seldom exceed 10 degrees.

The fault of Poor Valley ridge is evidently a cross fault. It continues into Tennessee and is crossed by Powell river.

The Region between Wallen's Ridge and Clinch River.—Wallen's ridge and Powell mountain are one in structure ; the valleys separating them are monoclinals ; and the beds shown on Powell mountain reached at one time to the crest of Wallen's ridge, or better, perhaps, to the fault which is the southerly line of the Poor Valley ridge. No detailed examinations were made beyond Powell mountain ; and the notes were obtained only while passing along the Estilville road from the head of North Fork gap to Clinch river. Some details respecting the conditions existing within a few miles further north-east were received from General Imboden, who had crossed Powell mountain into Hunter's valley.

If the reader will consult the map accompanying Prof. Lesley's memoir of 1872, he will see that Powell mountain curves somewhat sharply toward the south-east near the western edge of the map. This bend is due to erosion by a branch of the South Fork of Powell river, and marks no change in geological structure. A similar bend occurs at the North Fork, which is due to erosion by the North Fork of Clinch river.

There appears to be a general uplifting of the whole area south-westward ; for the dips grow gentler in that direction, and the synclinal between Wallen's ridge and Clinch river seems to grow shallower. The axis of elevation curves toward the south-west not far beyond the North Fork gap, and the dip on the slope of Powell mountain becomes south-east. The Carboniferous rocks do not extend beyond the North Fork gap ; and thence, as far as was examined, only the Upper Silurian rocks are shown on the slope of the ridge ; nothing newer than the Devonian black shales is present along the North Fork of Clinch river after it leaves the gap. Possibly the absence of the later rocks may be due in large measure to erosion. The Carboniferous rocks are well shown on the north-eastern side of the pass, until within two or three miles of the Clinch river. The axis of the synclinal was not observed. The Lower Silurian limestone was reached again on Stock creek, a tributary of Clinch, which within a mile of its mouth passes under a hill through a large tunnel excavated in the Trenton limestone.

This tunnel is properly regarded as a natural wonder. Its approaches are imposing, and the cliff of limestone, overhanging its mouth, is more than 450 feet high. A railway route was once surveyed through this tunnel, but the line was condemned as dangerous, since huge blocks of the limestone frequently fall from the overhanging cliff.

DRAINAGE AND EROSION.

Two forks of Powell river, Pigeon and Roaring, rise on the southern side of Black mountain and unite at the head of Big Stone gap, by which the resulting stream crosses the Stone Mountain fault. The South Fork of Powell river rises at the foot of Powell mountain near Little Stone gap; receives tributaries from the north side of that mountain as well as from the valley between it and Wallen's ridge; and, after crossing the fault of Poor valley ridge, by a shallow gap, joins the river at about a mile below Big Stone gap. Powell Mountain river flows between Stone mountain and Poor Valley ridge, for say fifteen miles, to opposite Pennington's gap, where it receives the North Fork. That stream rises on the slope of Black mountain and flows across the Stone Mountain fault by way of Pennington's gap. The main river, thus increased, flows southwardly for a little distance, and then crosses the fault of Poor Valley ridge.

The North Fork of Clinch river rises in the valley between Wallen's ridge and Powell mountain, and is separated by a low divide at its head from Wildcat creek, a tributary to the South Fork of Powell river. It flows along a monoclinal valley to the North Fork gap, which is sometimes known as Slemp's gap, where it turns toward the south-east. Within three or four miles, its course is again changed and the stream once more flows south-westwardly, following the foot of Powell mountain in a monoclinal valley.

Stock creek, another tributary to Clinch river, rises in Hunter valley, flows along the synclinal for several miles, then turns and flows up the dip to Clinch river. Clinch river itself rises far to the east of the region examined by me, and flows for a long distance near the line of the Stone Mountain fault, which it crosses and recrosses; but, at several miles east from the Little Stone gap, its course is changed, and the river for a while flows with the dip; but the course is again changed, and the direction becomes very nearly that of the strike.

It is sufficiently clear that the gaps through Stone mountain and Poor Valley ridge do not owe their origin to any convulsion of nature. The strike of the limestone and the conglomerate across Big Stone gap is perfectly true, and no evidence of a cross-fault or fracture is apparent there or in the coal-field behind the mountain. The absence of fracture is even more apparent in Pennington's gap through Stone mountain; for this gap is a tortuous passage-way with bold cliffs of the vertical conglomerate beds projecting from both sides. These cliffs afford ample evidence that erosion, not convulsion, produced the gap. The same condition is seen in the gap by which the South Fork of Powell crosses Wallen's ridge or the Poor Valley ridge fault. The North Fork gap in Powell mountain is as distinctly due to erosion as is the monoclinal valley along which the stream flows above the gap, or the tunnel by which Stock creek flows through a hill near Clinch river.

It may be stated positively that not one of the numerous gaps by which

streams cross the several faults and mountain ranges exhibits the faintest trace of any cross-fracture in the rocks.

At first glance, one might be inclined to suppose that the faults have influenced the direction of drainage. A deep valley has been excavated along the front of Stone mountain; another, digged out of the contorted limestone and shale of the Lower Silurian, follows the fault of Poor Valley ridge; the West Fork of Stone creek, a branch of Clinch river, has made for itself a broad valley near the Stone Mountain fault east from that of the South Fork of Powell river. These valleys arrest one's attention at once and they lie very near the lines of fault.

But valleys of equal importance are found where no fault exists to direct their course or extent. The monoclinal valley between Wallen's ridge and Powell mountain above the North Fork gap is as broad as the Turkey cove between Wallen's ridge and Poor Valley ridge; Wallen's valley, between Wallen's ridge and Powell mountain beyond the North Fork gap, is a monoclinal, and is one of the finest valleys in Southwest Virginia; the broad valley, followed by the North Fork of Clinch after it leaves the North Fork gap, is far removed from any line of faulting, and lies not far from the axis of the synclinal.

Erosion along the line of the Stone Mountain fault is interrupted, and the valley is far from being continuous; a well marked divide separates the South Fork from Powell river and a bold divide separates the South Fork of Powell from the West Fork of Stone creek. The condition is similar to that in the valley between Wallen's ridge and Powell mountain; for a low divide intervenes between Wildcat creek and the North Fork of Clinch, while a high divide separates the latter stream from Wallen's creek, which flows along Wallen's valley.

The conditions in the immediate vicinity of the faulted lines appear to differ in no essential feature from those observed in less disturbed localities. It is evident:

First. That the course of the streams has not been determined by the lines of fault.

Secondly. That erosion along the faulted lines is essentially the same in character and extent with that in localities where no faults exist.

At the same time one may not ignore the fact that the faults have done much to hasten erosion along their lines as well as along the lines of streams belonging to the drainage system of Powell river, although one may be inclined to exaggerate the extent of this influence by forgetting that that drainage system is the important one in the region examined, while only a fragment of the Clinch river system falls within the area.

There must have been drainage before the faults existed. Evidently the rocks were more or less flexed previously; for the dips in Wallen's ridge and Powell mountain are almost due east, whereas those on the northerly side of the faults are north-west to north-north-west. It seems not wholly improbable that the faults are of later date than the disturbance which pro-

duced the comparatively gentle synclinal between Wallen's ridge and the Clinch river.

The faulting process was not abrupt; though a geologist might think it so, for to him a thousand years is literally as one day, and the whole of the historical period is insignificant. But this process of elevation, fracture and lateral displacement, required a vast length of time. The corrasive force of the streams must have deepened the channel-ways as rapidly as the rocks were raised. It is quite possible that the present system of drainage is as old as Carboniferous times, and that the disturbance producing the faults led to comparatively little change in its direction.

Stated Meeting, September 17, 1880.

Present, 4 members.

President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the Physical Society in Berlin, Jan. 2, 1880 (102, 103, XV, ii); Astronomical Society at Leipsig, Aug. 20 (104, 105); Association for National Science in Würtemburg, April 30 (102, 103, XV, i, ii); Agricultural and Historical Society at Lyons, March 10 (1 to 16, 18 to 20, 22, 24, 25, 27, 28, 32, 33, 35 to 62, 65 to 96, 98); Royal Academy, Amsterdam, Oct. 24, 1879 (102, 103); Massachusetts Historical Society, 30 Tremont Street, Boston, Aug. 12, 1880 (106, List); Public Library, New Bedford, Sep. 1 (106, List); Yale College, Aug. 26 (106, List); University of the City of New York, Sep. 1 (106, List); Astor Library, Sep. 13 (106, List); Regents of N. Y. University, Albany, Sep. 3 (106, List); N. Y. Historical Society, Aug. 23 (106, List); Penn. Historical Society, Sep. 7 (106, List); Maryland Historical Society, Sep. 6 (106, List); U. S. Coast Survey, Washington, D. C., Aug. 21 (106, List); Chicago Historical Society, Aug. 23 (106, List).

Letters of envoy were received from the Geological Survey of India dated Geological Survey Office, Calcutta, March 18, 1880, signed H. B. Medlicott, Supt.; L'Academie Royale des sciences, lettres et arts de Modene, dated July 31, 1880; Geologisch-botanische gesellschaft, Wien, I. Herren-

streams cross the several faults and mountain ranges exhibits the faintest trace of any cross-fracture in the rocks.

At first glance, one might be inclined to suppose that the faults have influenced the direction of drainage. A deep valley has been excavated along the front of Stone mountain; another, digged out of the contorted limestone and shale of the Lower Silurian, follows the fault of Poor Valley ridge; the West Fork of Stone creek, a branch of Clinch river, has made for itself a broad valley near the Stone Mountain fault east from that of the South Fork of Powell river. These valleys arrest one's attention at once and they lie very near the lines of fault.

But valleys of equal importance are found where no fault exists to direct their course or extent. The monoclinal valley between Wallen's ridge and Powell mountain above the North Fork gap is as broad as the Turkey cove between Wallen's ridge and Poor Valley ridge; Wallen's valley, between Wallen's ridge and Powell mountain beyond the North Fork gap, is a monoclinal, and is one of the finest valleys in Southwest Virginia; the broad valley, followed by the North Fork of Clinch after it leaves the North Fork gap, is far removed from any line of faulting, and lies not far from the axis of the synclinal.

Erosion along the line of the Stone Mountain fault is interrupted, and the valley is far from being continuous; a well marked divide separates the South Fork from Powell river and a bold divide separates the South Fork of Powell from the West Fork of Stone creek. The condition is similar to that in the valley between Wallen's ridge and Powell mountain; for a low divide intervenes between Wildcat creek and the North Fork of Clinch, while a high divide separates the latter stream from Wallen's creek, which flows along Wallen's valley.

The conditions in the immediate vicinity of the faulted lines appear to differ in no essential feature from those observed in less disturbed localities. It is evident:

First. That the course of the streams has not been determined by the lines of fault.

Secondly. That erosion along the faulted lines is essentially the same in character and extent with that in localities where no faults exist.

At the same time one may not ignore the fact that the faults have done much to hasten erosion along their lines as well as along the lines o: streams belonging to the drainage system of Powell river, although on may be inclined to exaggerate the extent of this influence by forgettin that that drainage system is the important one in the region examined while only a fragment of the Clinch river system falls within the area.

There must have been drainage before the faults existed. Evidently th rocks were more or less flexed previously; for the dips in Wallen's rid and Powell mountain are almost due east, whereas those on the norther side of the faults are north-west to north-north-west. It seems not whol improbable that the faults are of later date than the disturbance which pr

[illegible]

gasse, Landhaus; Königliche Sachsiche gesellschaft d. W. Leipsig, March 1, and April 27, 1880; Physicalische gesellschaft zu Berlin, Jan. 1, 1880; L'Academie royale des sciences à Amsterdam, Jan. 31, 1880; and Verein für Naturwissenschaft zu Braunschweig, Aug. 23, 1880. (All through the Smithsonian Institution.)

Donations for the Library were received from the Geological Survey of India [Vols. I to XVII of *Memoirs* (except I, i, II, ii, out of print); Series II to XIII of *Palæontologica Indica* (Ser. I and II, v, out of print); and Vols. I to XIII, i, of *Records*]; Geological Survey of Victoria; R. Society of Tasmania; Imperial Academy at St. Petersburg; Imperial Academy, Anthropological Society, and Geological Institute at Vienna; Imperial Academy, German Geological Society, Physical Society, and Zeitschrift f. d. ges. Nat. at Berlin; Royal Saxon Society, Observatory, and Zool. Anzeiger at Leipsig; Verein f. Nat. at Braunschweig; Verein f. V. Nat. at Stuttgart; Neues Lau. Mag. at Görlitz; M. Prof. Reneviers at Lausanne; Royal Academy of Lynxes at Rome; Société d'Agriculture, &c., and MM. A. Falsan and E. Chantre at Lyons; Anthropological Society, Museum of Natural History, Annales des Mines, and Revue Politique, at Paris; Linnean Society, and Com.-Geological Society, at Bordeaux; Royal Belgian Academy; Royal Academy at Amsterdam; Victoria Institute, R. Astronomical, Meteorological, R. Geographical, Geological, Zoölogical, R. Asiatic, and Society of Antiquaries, and London Nature; Geological Survey of Canada; Museum of Comparative Zoölogy, at Cambridge, Mass.; Professor Ed. Pickering; Prof. Asaph Hall; American Journal of Science, Prof. Jonathan Edwards, New Haven; Mercantile Library Ass. N. York; Franklin Institute, Journ. Pharmacy, Med. News, Dr. B. H. Rand, Philadelphia; Journal of Mathematics, Baltimore; Smithsonian Institution, Geographical Survey of the Territories, Chief of Engineers, Surgeon General's Office, and National Museum, at Washington; S. W. Burnham of Chicago; Missouri Historical Society; Geographical and Statistical

Society; Revista Scientifica; Ministerio de Fomento, and Meteorological Observatory of Mexico.

The following record was read from a letter from Mr. John Biddle, dated 1344 Pine Street, Sept. 8, 1880, for correcting the Society's List of Members.

James Biddle, eldest child of Wm. Biddle and Mary Scull, and brother of Edward Biddle (member of the first Colonial Congress); also of Nicholas Biddle (commander of the Colonial frigate "The Randolph"); also of Charles Biddle (member of the Supreme Court); was born Feb. 18, 1731; married Miss Frances Marks, June 30, 1753; died June 14, 1797. He was elected Prothonotary of the County of Philadelphia, Nov. 13, 1788, and appointed Judge C. P. for the County, Nov. 25, 1788.

The death of the Rev. Professor E. B. Andrews at Lancaster, Ohio, Aug. 21, 1880, in the 60th year of his age, was announced by the Secretary.

The death of Professor Samuel S. Haldeman, at Chicques, Lancaster county, Sep. 10, 1880, aged 68, was announced by the President, and on motion of Dr. LeConte, Dr. D. G. Brinton was appointed to prepare an obituary notice of the deceased. Dr. LeConte in making this motion said:

He was an accurate observer and a close student of nature during the earlier part of his life, which he gave to Zoology. Afterwards, when, by the failure of his eyesight, the minute inspection of specimens necessary to progress in any branch of Biology became no longer possible, he devoted himself to Linguistics and Archæology.

It may be here observed, that the correctness in observation and the logical accuracy in reasoning which in these days are the special characteristics of biological and physical research, and which he had acquired by his zoological studies, were in the change of pursuits of great benefit.

He carried into his new studies all the mental advantages which he had previously obtained from his varied investigations in Natural History. The relations of articulate sounds, the changes in sonance of words, their growth and complication by affixes and suffixes, were all studied in reference to the mechanism of the vocal organs, and the results educed were traced to the combination of those organs with the directing power of the brain, for the expression of intelligent language. But in regard to the minutiæ of his contributions to this branch of science, I know but little, and am not qualified to speak. I know only of his successes, with which all his friends sympathized, and of which the nation has reason to be proud.

In fine, he was an example of those rare individuals who, inspired by a true love of knowledge, pursue it according to their ability, without thinking of pecuniary reward or personal approbation. Such are the men who furnish the germs for future advancement in the realms of thought. Happy are those who are able to number them among their friends.

A communication was presented, entitled "Notes on the Cumberland or Potomac Coal Basin, by Howard Grant Jones, M. S."

Mr. Lesley drew attention to a remarkable feature of the section accompanying this paper, according to which both the Mountain limestone and the Mauch Chunk red shale formations are *duplicated*, and that upon a grand scale; the Upper red shale being 375 feet thick; the Upper limestone 301′ (followed by 70′ of gray shale); the Lower red shale 2000′; and the Lower limestone 475′ (underlaid by shale, flints and iron ore, 300′); making the total apparent thickness of N, XI (counting in 200′ of green shales over the Upper red shale) between 3700′ and 3800′, a thickness even greater than at Pottsville in Schuylkill county, Pa. The duplication of the limestone formation in the column ought to have an important bearing upon the sub-division of the sub-carboniferous limestone group in the Western States. It may help to explain some of the prevailing confusion respecting the limestones exposed at apparently different horizons in Northern Pennsylvania.

Mr. Lesley proposed another Greco-Egyptian etymology, viz: *Ιακχος* from [Hor-m-] aχu, the Sphinx name of the Solar disc on the horizon.

He remarked that *Ιακχος* was the well-known Sun-god of the Eleusinian Mysteries, represented as suckled by Ceres; as Horus is frequently represented in the act of sucking the breast of Isis. The torch-flinging performance along the road from Athens to Eleusis represented no doubt the westward progress of the morning light.

Ceres was the mother of mystery, the darkness out of which the Sun is born, and the underground concealment out of which all vegetable life springs forth. Her name must be connected with the mystical celtic word *Cær*, the root of so large a mythical nomenclature; the equivalent of the full oriental form *Cabar* (or *Cabal*), and the key to the later Cabala. Hundreds of geographical names like Corinth, Carinthia, &c., embody it very plainly.

The destruction of *Ιακχος* by the Titans, as well as their destruction by Zeus, are myths explainable by the obstruction of the Sun's rays by mountains, and the victory of the Sun at the zenith. The part played by mountains in Solar mythology is shown by the ideograph of the name of the Sphinx, Hor-m-aχu; and is illustrated by the morning admiration of travelers on the Nile. It is much better to seek for the primitive ideas among the every-day phenomena of nature, than among the poetical and metaphysi-

cal inventions of later and more intellectual ages, when the victory of truth over error replaced that of day over night in the language of the initiated. We must come down to the classic age of the XIX dynasty before this spiritualizing process of the poets of the priesthood becomes well authenticated.

The connection of Ormuzd, Horus and the Shemitic *aur*, light, is evident; but the relationships of *lux*, *fax*, and *ox* (oculus, *ὤψ*) and of *lux* with *ῥεῖν*, *ruere*, and of *fax* with *λύχνος* will also repay an effort at development.

The President reported that he had received a letter from Drexel, Harjes & Co., of Paris, advising that the sheet allowed for the receipts of interest on the 3 per cent. French Rentes, belonging to the Michaux Legacy had been filled up. The rules of the French Treasury require that a new sheet and inscription shall be made in the name of the Society. They forwarded the proper petition to the Minister of Finance for that purpose which has been duly signed by the President and Treasurer in the presence of the French Vice-Consul at Philadelphia, and the same duly and officially certified by him as required by the laws of France, and such petition has been sent to Messrs. Drexel, Harjes & Co., at Paris.

And the meeting was adjourned.

Notes on the Cumberland or Potomac Coal Basin. By Howard Grant Jones, M. S.

(Read before the American Philosophical Society, September 17, 1880.)

This field is a long triangular territory of about sixty miles in length, lying along the outside or eastern edge of the great Alleghany uplift, and is situated in Somerset county of Pennsylvania, Alleghany county, Maryland, and Mineral county, West Virginia. Although considered a spur, the basin is rather an overlapping of the Coal strata to the eastward of the Alleghanian fold which demarcates the celebrated Coal fields of those States. It is with Broad Top and an unexplored basin in Alleghany county (New River) the only deposits beyond this line. On leaving Pennsylvania this persistent anticlinal becomes "Savage Mountains," which bend south west towards a geological center at Union, in Maryland, where are pinned together the southern extremities of the several basins of Maryland and Pennsylvania lying parallel to the Alleghanies. The Coal strata here flow over Savage mountain into the Potomac basin, virtually terminating this range in the general elevation. The name and bold characteristics of

the Alleghanies are here, however, taken up by a range of mountain fifteen miles to the eastward, forming the border of the field (Davis mountain of Maryland, and Front ridge of Virginia). Union is a point situated on the great swell or uplift in northern West Virginia pointed out by Professor Rogers.

The rocks of Savage mountain are composed of the Mauch Chunk Red Shales and Limestones (XI) and the overlying Conglomerate (XII). They fold under the field with a dip of from 10′ to 20′, and rise up again in Davis mountain, five miles beyond, with a reverse dip considerably strengthened. There is a line of upthrow lying east of the basin, running along the outlying red shale valley, composed of the lower limestones, the flint and the hard sandstones of X and IX (Pocono and Catskill).

Wells' Creek mountain at the northern end of the basin, is flanked by the uplifted Pocono sandstone and crowned by the same, as it returns and dips down the east flank, on its way under the town of Cumberland. It carries here on its back the overlying slates and flints, iron ore and lime strata of XI. A range of little mounds dotted along between the basin and this mountain range shows the harder limestones on edge. In Wells' Pass, under the curve or anticlinal of the Pocono sandstone, is to be seen the red sandstone of IX, though quickly returning.

Knobby range, further to the south, towards Piedmont, probably carries the Great White Sand (X), since at Keyser we find the lower limestones of the red shales and the underlying flints upturning east of the town and the New Creek ridge, and just west of the range. The Mauch Chunk shales (XI) show on the Potomac, near Keyser, dipping 45° to the northwest.

The accompanying section has been made at different points on George's creek, from Barton to Piedmont and on Potomac to Keyser. It includes the Coal Measures, from a seam 400 feet below the Pittsburg Coal; possibly the Conglomerate Series; the duplicate beds of red shale and limestones to the Great White or Pocono sandstone. The intervein strata to the Great Bed has already been published in Tyson Section, Plate VI, Report HHH.* The Lower Barren group of coals are here distinctly shown with their fossil limestones and sandstones, down to the Mahoning SS. Founded on the existence of the underlying Ferriferous limestone at Stony river, Prof. J. P. Lesley some time ago identified the Upper Bloomington or six feet coal of this basin as the lower Kittaning seam. This is now proved by the discovery of the fire-clay and limestones on the Baltimore and Ohio R. R., and the lower iron and clay deposits to the Piedmont SS.

The unveiling of the Conglomerate series of sandstones is important, showing a total thickness of 560 feet, from the Piedmont sandstone down to the lowest bed of coal. This series has its coal deposits through its entire thickness, though not largely developed. But at least one workable large seam has been noted, but has been omitted because of the uncertainty of its proper position.

* Report of Progress of Second Geological Survey of Pennsylvania, Somerset county, by F. & W. C. Platt.

The existence of a green shale and sandstone deposit of 200 feet, underlying the Conglomerate series and carrying an undeniable print of its relation to the Mauch Chunk shale in the red-hued earth topping it.

The most noticeable feature is the doubling of the red shale and limestone deposit of XI. There are two distinct series, under no condition possibly to be confounded or misidentified. The upper of 375 feet, red shale and black (fossil), red and gray limestone of 200 feet underlying; the lower of 2000 feet red strata and 450 feet gray limestone. Both series being fossiliferous in the upper part.

Another feature is the shale, flint and iron ore deposit, 300 feet, underlying the foregoing groups and separated from the red rocks of IX by the only heavy sandstone (Pocono SS.) at this horizon. It is a pure, hard, solid white rock.

Section of strata from Lower Barren Measure to Pocono Sandstone, as found on George's Creek and the Potomac River, Western Maryland and Virginia, June, 1880.

24′ Sandstone. See base of Prof. Tyson's Section, Plate VI, Report H. H. H., Second Geological Survey, Penna. The strata from this sandstone to the Pittsburg seam and higher are there given.

39′ Shale. Lower three feet contains Neuropteris, Calamites, Pecopteris. 6″ Slate Bland fine gr., containing Neuropteris augustifolia, Loschii and tenuifolia.

3′ 3″ *Coal. Hampshire Seam.*, probably same as Coleman bed of Somerset Co., Pa. It is 3′ 3″ at Barton, 4′ 10″ near Piedmont, 5′ on Savage river near Bloomington, 3′ 10″ on Sharpless Hill, ten miles to the southward. It is probably the "Rock Coal" of Millersburg, Pa. It is characterized by bottom slate, shale roof, salmon-colored ash from lower bed, and ferns. It is the most widely known bed in the basin except the Six foot (Kitt.). It is 388 feet below Pittsburg seam, Barton; 4′ 10″ at Moore's run, 347 feet Hampshire Co., Virginia, workings near Piedmont. It runs from 2.5% ash at bottom to 15% ash at top of bed; and sulphur in same relations from .57% to 1.75%.

10′ Fire-clay containing more or less balls of iron. Blue color.

6′ Limestone.

15′ Sandstone.

12′ Shale.

10′ Sandstone.

3′ 2″ *Coal. Bartlett's Run seam.*

10′ Black slate.

6′ Shale.

4′ 9″ Fire-clay. Impure.

9′ 9″ Sandstone.

9′ Gray shale.

6′ 2″ Marius shale. One foot fossiliferous limestone at top.

4″ *Coal.*

5′ 5″ Sandstone.
5′ 2″ Shale.
1′ 6″ *Coal.*
1′ 4″ Shale.
5′ Fire-clay.
5′ " sandy.
50′ *Sandstone pebbled. Mahoning S. S.?* Not identified north of Frostburg. At Barton and below it is a hard, fine-grain half-bedded pebbled rock of 40 feet. At Crooked run, 12 miles south of Piedmont, it is fully pebbled. On Stony river, further south yet, it is simply a mass of agglutinated pebbles of 60 feet.
5′ Shale.
1′ 10″ *Coal.*
20′ Shale, with limestone at bottom.
6′ Shale.
4′ Sandstone.
4′ Iron ore, clayey.
5′ Fire-clay. Free from balls of iron and plastic.
5′ *Coal.* Bear's Hollow Coal, Morrison's seam. Near Barton it is 3′ 4″. At Bloomington it is 5′, at Piedmont 5′ 6″, and at Sharpless' Hill 5′ 2″, and further south much thicker. It is characterized by hard nature of the coal and its fire-clay roof and floor. Contains little pyrites and yields 5% of ash, gray. It runs about 40′ under the Mahoning pebble rock above and 175′ over the Upper Bloomington seam (Kittan.). It runs 200′ to 220′ under the Hampshire Coal, at the head of section.
10′ Fire-clay.
10′ Sandstone.
20′ Shales.
2′ 8″ *Coal.*
2′ Clay.
15′ Sandy shale.
1′ *Coal.*
10′ Fire-clay and shale. Fire-clay and shale containing iron ore in center of bed.
10′* Hard sandstone. Reddish color.
10′ Black slate.
3′ Sandstone.
30′ Shale. Containing marine shells and a reputed coal.
40′ Sandstone.
10′ Shale and black slate.
5′ 6″ *Coal.* Upper Bloomington seam. Kittanning Lower Coal. It is probably the "Savage" seam of Millersburg. At Piedmont it is 5′ 6″; at Bloomington, 5′; McCorbin's hill, 7′ 2″; Rinker's hill, 8′ 3″; at Falls Stony river, 9′. Characterized north of Piedmont by middle slate, calamite tufts in roof overlying sandstone and fire-clay flow. In

lower part of basin by heavy top slate and the unusual size of seam, as above. It is a bright, soft coal, yielding 7% gray ash and somewhat sulphury. It runs from 70 to 90 feet over the Piedmont sandstone, and 750 to 800 feet under the Pittsburg seam.

10′ Clay and ore.
2′ Sandstone.
8′ Limestone.
12′ Sandstone.
4′ 10″ *Coal.*
5′ Clay.
4′ Shale.
1′ Iron ore.
7′ Shale, clay and sandstone.
5′ Clay, pure. Fine clay bed. It is probably much thicker than this within the mountains, and resembles in appearance and quality the Mt. Savage clay bed. (See below.)
22′ Sandstone. Sometimes found pebbled, as if indicating the approach to the conglomerates.
1′ 8″ *Coal.*
10′ Fire-clay.
30′ *Sandstone. Piedmont Sandstone.*
4″ *Coal.*
41′ Sandstone and shale.
11′ Sandstone pebbled.
2′ 6″ *Coal.*
12′ Shale.
38′ Sandstone.
2′ 6″ *Coal.*
58′ Unknown, shaly.
38′ Sandstone.
42′ Shale.
1′ 10″ *Coal.*
5′ Shale.
48′ Quartz sandstone.
1′ to 4′ *Coal.*
8′ Clay. Mt. Savage. It is a pure shale clay of great standing power. It thickens to 16 feet at places, and lies in rolls or pockets in a sotter and semi-plastic clay lying under it. It contains but little iron or potash. It has been opened at Williams station, Somerset Co., Pa., and at Ellerslie, Pa., also near Mt. Savage, and is found cropping along the crest of the mountain on each rim of basin.
4″ Slate.
6″ *Coal.*
60′* Sandstone conglomerate, with vertical split.
15′ Shale.
55′ Sandstone.
6″ *Coal.*

22′ Shale interval.
35′ Sandstone.
20′ Thin shaly sandstone.
1′* *Coal.*
5′ Black slate.
20′ Sandstone.
1′* Lowest *coal.*
14′ Shale.
10′ Red bluish shale.
75′ Shale.
40′ Sandstone, hard.
50′ Green shale.
10′ Sandstone.
375′ Red shale.
40′ Fossil *limestone.*
28′ Green shale to reddish.
8′ Red *limestone.*
4′ Red sandstone.
30′ Red *limestone.* Not fossiliferous.
100′ Impure and interstratified *limestones* and sandstones.

Upper Limestone of the Mauch Chunk shale, same as found in Youghioghany valley, called "*Sang Kine* limestone."

80′ Gray, wavy *limestone*, showing washings or waves of color in structure.
20′ Undetermined.
50′ Sandstone.
2000′ Red shales.
440′ Limestone strata, fossilliferous at top; 40 feet pure cement limestones at bottom.
300′ Brown shale and flints, containing *iron ore beds at base.*
80′ to 100′ Pocono sandstone.

Résumé.

Lower Barren and Sub Lower Coal Measures		563 ft.
Conglomerate Measures	XII	500 "
Green Shale and Sandstone	XI	200 "
Red Shale (Upper)	XI	375 "
Limestone (Upper)	XI	301 "
Gray Strata	XI	70 "
Red Shale (Lower)	XI	2000 "
Limestone (Lower)	XI	475 "
Shale Flints and Iron ore	XI	300 "
Pocono Sandstone	X	100 "
		4944 ft.

Stated Meeting, October 1, 1880.

Present, 6 members.

President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from Prof. Ira Remsen, dated Baltimore, September, 24.

Letters of acknowledgment were received from the Philosophical Society, Glasgow, Sept. 11 (105); Museum of Comparative Zoölogy, Cambridge (106); and Mr. J. H. Crane Coffin, Sept. 18, 1880, Washington, D. C. (106)

A letter of envoy was received from the Royal Observatory, Greenwich, dated Sept. 1, 1880.

Donations for the Library were received from the Royal Academies at Berlin and Brussels; the Zoölogischer Anzeiger; Royal Venetian Institute; Revue Politique; London Nature; Prof. Richard Owen; Free Public Library, New Bedford; American Chemical Society; Prof. E. D. Cope; U. S. Bureau of Education, and the Kansas Historical Society.

The Secretary reported that Dr. Brinton accepted the appointment to prepare an obituary notice of Prof. S. S. Haldeman.

Mr. Fraley reported that the address in memory of the late President, George B. Wood, M.D., LL.D., prepared at the request of the Society, by Dr. Henry Hartshorne, would be delivered in the Hall of the College of Physicians, on Monday evening, Oct. 11, at 8 o'clock.

Pending nominations, Nos. 904, 909 to 919, and new nomination, No. 920 were read, and the meeting was adjourned.

Special Meeting, October 11, 1880.

(In the Hall of the College of Physicians.)

President, Mr. FRALEY, in the Chair.

After an introduction by the President, Dr. Hartshorne addressed the members and invited guests of the College of

Physicians, the Trustees and Faculties of the University of Pennsylvania, Jefferson Medical College, and Woman's Medical College of Philadelphia, and the Managers of the Pennsylvania Hospital, and Philadelphia Dispensary, as follows:

Memoir of George B. Wood, M.D., LL.D.,

By Henry Hartshorne, A.M., M.D.

(*Read before the American Philosophical Society, October* 11, 1880.)

With a long life, not much varied in events, nor brilliant in deeds that meet the public eye, Dr. George B. Wood may be named as one who, in the main features, and, indeed, in almost every particular of his career, has left an example worthy of admiration and emulation. It will be acknowledged by the least enthusiastic of his friends and associates, that he was one of the most useful men of his generation.

He was born at Greenwich, in New Jersey, in the year 1797. His own memoranda of his ancestry are not devoid of historical interest in connection with the early settlement of this city, as well as that of our neighboring State. It appears that Richard Wood, a member of the Society of Friends, came to this country with William Penn in 1682, bringing with him his son James, and settled in the northern part of the then new city of Philadelphia; where Wood street probably received its name from him. There is reason to believe that while James Wood remained in the city, another younger son or sons of Richard Wood went to New Jersey, locating themselves in Salem and

Gloucester counties; Woodstown and Woodbury being, in all probability, named after them.

Farther back, in Gloucester, England, traces have been found of the family annals, through the Woods of Brockrup in the 16th, and of Gobril in the 15th century, to a still earlier period, when their predecessors inhabited for many successive years the ancient Court-House of Gloucester; now, long since, converted into a farm. Late in Dr. Wood's life, he was informed of the decease of a very wealthy banker, named James Wood, in Gloucester, England, without direct heirs. Legal gentlemen called upon Dr. Wood, proposing to dispute this banker's will, in his favor, as a collateral heir; the property having been left to an alderman named Wood, in London. While declining this proposition, Dr. Wood remarked upon it as follows: "Had the existence of such relations been known to Mr. Wood, and especially had accident brought us into close intimacy or association, it is not improbable that he might have preferred persons of his own blood as the heirs of his fortune, to one whose only claim upon him was the name of Wood, and a few flattering attentions."

Two sons of James Wood of Philadelphia, above mentioned, early in the 18th century left this city to settle in Southern New Jersey; probably under the auspices of Thomas Chalkley, a prominent member and preacher of the Society of Friends; who contemplated founding, upon the banks of the Cohansey river,

a great city which might rival Philadelphia. Before that time, as early as 1683, the same design had been formed by John Fenwick, who became Proprietor of West New Jersey by conveyance from Lord Berkeley, successor to the Duke of York, afterwards James II., who was grantee of the Crown. Fenwick left a will, directing a city to be erected near the Cohansey, which he willed thereafter to be called Cæsarian river. All that followed this large project, however, has been the growth of the small town or agricultural village of Greenwich.

Dr. Wood kept in his possession a deed, signed by the agent of William Penn, who acted as executor of John Fenwick, conveying a lot of ground forming a part of his Greenwich farm.

In each generation, the heads of this family in New Jersey have been men of consideration and local distinction. Richard Wood, the father of the subject of this memoir, was a man of superior mind and strong character, much respected by all who knew him. He was described by an acquaintance, speaking of him to Dr. Wood, as "a prince of a man." He married twice. His second wife, mother of George Bacon Wood, was Elizabeth Bacon, of Bacon's Neck, New Jersey. Of the early settlement of her family in that part of the country, evidence is preserved. One or two memoranda may be here interesting: "1683, June 25th, Shank-a-num and Et-hoe, Indians, convey to John Nichols, of Nichols' Hartford, near Cohansey, 100 acres of land,

part of the tract known to the Indians as Cat-a-nun-gut, adjoining lands of Samuel Bacon and others."

"1685, August 12th, John Nichols and wife convey 100 acres of land to John Bacon of Cohansey."

George B. Wood was the eldest son of Richard and Elizabeth Bacon Wood. At twelve years of age, his earnest desire for a liberal education was gratified by his father sending him to school in New York. When sufficiently prepared, he was transferred to the University of Pennsylvania, where he was graduated, with honors, in 1815.

Of his early life I have obtained but little particular account, beyond what is preserved in his own manuscripts. These show a very active mind, more alive with imagination and sentiment than would have been supposed by those acquainted only with his later labors. He wrote, between 1813 and 1825, many verses, mostly in English, some in Latin; amongst the former, several translations from the German of Schiller. With the German language, as well as the French and Italian, he acquired considerable familiarity; which was of use not only in his later arduous professional studies, but also in his very diversified general reading, and European travel. His library contained many books in foreign languages. It may surprise some who have known him as a most industrious student, and the author of ponderous medical works, to learn that he read quite a large number of novels; especially during his summer vacations. More remarkable

still, he planned, and wrote the greater part of a novel of his own; which I have seen in manuscript. It was never published.

Amongst the papers above referred to there is, under the date of 1814, "An Oration spoken before the Citizens of Philadelphia, on the Independence of the United States." This was delivered a year before his graduation at the University. In the year 1817, he contributed to Poulson's American Daily Advertiser a very spirited reply to an aspersion upon the Society of Friends, charging its members with a want of charity outside of their own borders, which had been published in the Portfolio of that day. The editor of the latter periodical replied, withdrawing, or essentially modifying, his injurious expressions.

Upon leaving the Collegiate Department of the University, young Wood began the study of Medicine as the office student of Dr. Joseph Parrish. His advantages there were decidedly superior; and he availed himself of them so well as to become, after his graduation in Medicine at the University in 1818, his preceptor's associate in giving instruction to students. A private medical school grew out of this association; in which a number of our most eminent physicians and surgeons, of the generation now passing away, took part, first as pupils, and some of them afterwards as instructors. Under such circumstances, Dr. Wood matured those convictions upon practical medicine and medical ethics which he inculcated through his whole

life; and which, during the forty-two years of his continuous labors as a medical professor and clinical teacher, were spread broadcast throughout this country. No one man has ever done so much as he, to form and influence medical opinion in America upon both practical and ethical questions. Well has it been for the profession, that his teaching was dictated by good judgment, careful study, and, above all, the highest principles of rectitude and honor.

Dr. Wood's first course of lectures was one upon chemistry, delivered to a non-professional audience, chiefly composed of ladies, in Dr. Joseph Parrish's private office. Here, in a lay course, as Dr. Littell observes, in a Memoir* to which I am much indebted for information, "before a class entranced by his carefully prepared experiments and not likely to be hypercritical in its judgments, he gained confidence and dexterity, and was thereby better fitted to perform his part in a more formal and important sphere." There was a tradition amongst medical students and others, that Dr. Wood was not, at the beginning of his work as a teacher, an easy, fluent or graceful speaker. It is entirely accordant with what we know of his whole life, to suppose that this may have been true; and that his having become, in maturity, one of the most admirable and successful lecturers of his time was due far less to any natural gift of eloquence than to assiduous and long continued exercise and cultivation of his powers.

*Read before the College of Physicians of Philadelphia, October 1, 1870.

Shortly after the Philadelphia College of Pharmacy was founded, in 1821, Dr. Wood was invited to become its Professor of Chemistry. He accepted the position, and held it, with success and popularity, from 1822 to 1831, when he was transferred to the Chair of Materia Medica in the same institution.

In 1835, when the Chair of Materia Medica in the University of Pennsylvania (before held by Dr. John Redman Coxe) became vacant, Dr. Wood was elected to occupy it. I have had before me a letter addressed by him, during the canvass, to James S. Smith, one of the Trustees of the University, at the request of the latter, in which, with modesty and yet with distinctness, he sets forth some of the reasons, growing out of his abundant preparation, for his claim of eligibility to the chair. He mentions in this letter the fact, that during the year 1829 he devoted all his leisure for nine months, in conjunction with Drs. Hewson and Bache, acting as a Committee of the College of Physicians, to the revisal of the Pharmacopœia of the United States. So many alterations were found to be required, that it was necessary to rewrite almost the whole work. Before the Committee was satisfied, Dr. Wood states that he had written all of the manuscript copy at least twice over with his own hand. Through its subsequent adoption by a National Convention at Washington in 1830, this Pharmacopœia became the standard authority for the preparation of official medicines throughout the United States; and it

has so continued, with repeated revisals, down to the present time. Not long after completing this important work, Professor Wood began, with Professor Franklin Bache, aided for a time by Daniel B. Smith, then President of the Philadelphia College of Pharmacy, a very elaborate commentary upon the Pharmacopœia, under the name of the United States Dispensatory. This, which made a volume of more than a thousand large and closely printed pages, was begun and finished by its authors in less than two years. It has, since that time, passed through fourteen large editions; the aggregate number of copies sold, during Dr. Wood's life-time, amounting to 120,000 copies; as it has long been regarded as everywhere indispensable to both the medical and the pharmaceutical professions. The intimate association of Doctors Wood and Bache, in the preparation of this most useful work of reference, was only a part of the fabric of their life-long fraternal friendship. This close intimacy was the more remarkable on account of their being opposed in interest as professors in the two great rival medical schools; that of the Medical Department of the University of Pennsylvania, and the Jefferson Medical College of Philadelphia.

In the professorship of Materia Medica and Therapeutics in the University of Pennsylvania, Dr. Wood reached the culmination of his reputation as a public Teacher. He was one of the leaders in that great reform in instruction upon scientific subjects, which

has now become universal; in which illustration and demonstration, by the constant presentation of objects to the sight, are prominent and essential. His courses of lectures upon Materia Medica may be truly said to have been splendid, almost magnificent; adorned as well as made complete for the students' information, by the exhibition, from day to day, of living specimens of medicinal plants from all quarters of the world, grown in his own private conservatory and botanical garden, maintained for this special purpose. When such could not at the time be obtained, fine pictorial representations were placed before the class in their stead; and his cabinet of mineral and other crude and prepared specimens was correspondingly complete. A printed syllabus of the course of lectures, interleaved for note-taking, was furnished gratuitously by him to each student. It may be said, indeed, that no portion of the curriculum of the Medical Department of the University, able and renowned as have been the other members or its Faculty, ever added more to the great reputation and large classes of that institution, than this model course. Dr. Wood continued to hold the Chair of Materia Medica and Therapeutics until 1850, when he was transferred to that of the Theory and Practice of Medicine, upon the retirement from the latter of Professor Nathaniel Chapman. This chair he retained until 1860, when he withdrew from all active professional labors.

Among other literary contributions of the earlier

portion of Dr. Wood's professional life, one not without importance was, his taking prominent part in the editorship of the North American Medical and Surgical Journal. This quarterly periodical attained the highest standing, being conducted by a number of gentlemen of ability and learning; although it gave way, after a few years, to a successor in the same field, under circumstances more favorable to a permanent existence.

In 1835, Professor Wood was appointed one of the attending physicians to the Pennsylvania Hospital. The duties of this responsible post he performed, with unremitting faithfulness, until the year 1859. His clinical lectures in that institution, to numerous classes of medical students, were admirable. Great improvements in the methods of ascertaining conditions of internal disease, and especially in the physical diagnosis of affections of the lungs and heart, were brought hither from Europe after Dr. Wood had begun his career as a medical teacher. Having no ultra-conservatism in regard to novelties, he applied himself to the practical study of auscultation and percussion; so as to become proficient in their bedside use. Not content, however, with his own skill in these newer methods, he availed himself, not unfrequently, of the assistance of the late Dr. W. W. Gerhard, with whom they were a specialty, in the diagnosis of cases under his care in the Hospital. It was one of Dr. Wood's characteristics, that, in his earnest and conscientious so-

licitude for the interests of his patients and pupils, he was always ready to supplement and extend the advantages of his own personal instruction, by engaging, upon the most liberal terms, the services of others in particular departments. This was constantly done by him in regard to his own private students, of whom, until about the year 1855, he always had a large class. Several of our most distinguished physicians, now leading practitioners and professors, can look back with grateful reminiscences to the hours advantageously spent, in review of their University studies, as Professor Wood's office pupils.

No event in Dr. Wood's life was of more cardinal importance to him than his marriage; which took place in 1823, to Caroline, only daughter of Peter Hahn, a wealthy merchant of Philadelphia. Congenial, domestic in her tastes, and devoted in her attachment to him, she was able, also, by her receipt of large means from her father, to secure her husband in an independent position in the world. Some men would have availed themselves of this, to withdraw from care and toil of every kind, and to enjoy their leisure in travel and in social or literary recreation. Not so with Dr. Wood; while generous, and sometimes even stately, in his mode of living, he employed the resources placed within his reach mainly in enlarging and improving his processes of instruction; into which, as well as into the composition of his books, he threw all the energy of his nature. It was a familiar fact to his contemporaries in

the medical profession, that the neediest practitioner, lecturer or author among them all, seldom worked so hard, and so incessantly, as Dr. Wood. The motives which sustained him in these laborious habits, were, evidently, not at all a desire to accumulate farther wealth, but a love for his pursuits, *per se;* a very earnest purpose of usefulness to his fellow-men; and, it may be, a not ignoble valuation of his own reputation.

Although without offspring, the companionship of his excellent wife was to him a constant source of happiness, until her death in 1865. With this loss, following that of Dr. Bache in 1864, began the decline of Dr. Wood's vigor, which slowly, and almost insensibly, proceeded, until his decease in the Spring of 1879.

In 1847, before his transfer to the Professorship of Practice of Medicine in the University, he published his great treatise, in two volumes, on the Practice of Medicine. This was at once recognized, at home and abroad, as an authoritative work. It became a favorite text-book for students, not only in this country, but also in Great Britain. The time-honored University of Edinburgh was one of several foreign medical schools in which it was officially approved and adopted. It passed, during its author's life, through six editions.

This work was followed, in 1856, by another, also in two octavo volumes, a treatise upon Therapeutics and Pharmacology. Of this, three editions were issued; the last in 1868. In both of these works, Dr. Wood showed the most indefatigable industry and excellent

judgment, in research, selection and arrangement, of all the knowledge obtainable upon his subjects. In neither is there manifested much originality of invention, discovery or suggestion. Exception may, however, be made to some extent upon this last point, so far as to say that he always exhibited great readiness, and sometimes ingenuity, in accounting for things which, to many others, seemed difficult to explain. I never knew him to be without a probable hypothesis, when one was wanted for such a purpose, whether in pathology or therapeutics, or in social or political affairs.

Dr. Wood's mental outlook was, indeed, far from being narrow, or in any sense restricted to matters connected with his own profession. He was earnestly and actively interested, for several years, in the establishment of Girard College according to the designs of its endowment. There is amongst his papers, in connection with this, a communication to the *Philadelphia Courier and Enquirer* of the date of Monday, Dec. 28, 1840, a really eloquent appeal to the citizens of Philadelphia, signed "Girard;" in which the philanthropist is personated as calling from his grave upon those to whom his trust had been confided, to end their long delay in the fulfilment of his cherished purposes for the benefit of the orphans of the City and State of his adoption. A few words from this paper may be here not inappropriately cited, as an example of its author's style.

"I entreat you," he writes, "by our former fellow-

ship and by all the good which I have intended for you and your children, I require of you by the obligation of an accepted trust, I conjure you by the terrors of a wounded conscience and a retributive judgment, to guard faithfully the sacred pledge which I have deposited with you. Should any one attempt to violate its sanctity, and abuse it for some unholy purpose, let him feel the weight of your indignant reproof. Should a public servant dare to propose a dishonorable application of it to your own wants or necessities, frown him into that contempt which every pander merits. If injury has accrued from former neglect, do all that you can to remedy the past and to guard the future."

In presenting this appeal to the public, after nine years had elapsed without any application of Stephen Girard's legacy to the education of orphans, it was understood that its author represented, although informally, the wishes of the Trustees of the College.

Shortly afterwards, Dr. Wood, as chairman of a committee of the same Board of Trustees, prepared a formal communication to the Select and Common Councils of Philadelphia, urging immediate action to carry out the provisions of Girard's will, by legal enactments and appropriations. The result of this conflict, however, between the Councils and the Board, was the dissolution of the latter, of which Nicholas Biddle was then President; and, also, the termination of the official connection with the College of its first President, Alexander Dallas Bache.

An important contribution was made, also, by Dr. Wood, to the organization of Girard College, in the form of a report of a committee of which he was chairman, upon the clothing, diet, etc., of its orphan pupils. This report comprised a brief but clear and systematic statement of the principles essential to the healthy conduct of such an establishment; such as, if carried out, must have secured to it from the start, excellent sanitary conditions.

Among other subjects upon which Dr. Wood wrote well, as he did upon all topics which interested him at all, was that of the Temperance reform. He contributed to the *United States Review*, in January, 1834, an article about fifty pages in length, on the "Temperance Cause." His views, in this article, were *advanced* for that day, although confined to an exposition of the evils attending the use of ardent spirits as a drink, and of immoderate indulgence in the use of fermented beverages. That, with longer reflection and experience, his mind did not greatly change upon this subject, was shown by a note appended by him to a reprint of the above mentioned article, in 1872. "Were our efforts confined," he there says, "to the exclusion of ardent spirit or distilled liquors from use, there might be some hope of success in the end; as a people among whom temperance could be established, with this limitation, could never, so long as the rule continued, become a nation of drunkards."

It may be remarked that Dr. Wood's retired position

in his later life may have debarred him from a close acquaintance with that pressure of facts in regard to the effects of intemperance in our own and other countries, which, with the evidence that the limitation which he urged cannot be anywhere extensively carried out, has brought many cautious minds in our time to conclude, that, to control what seems, next to war, the chief destroyer of modern nations, no prohibition, no personal or general sacrifice can be too great. It may be proper to say here, also, that, in his own way of life, Dr. Wood, while very fond of hospitality, and making his house a favorite social centre, especially for the members of his own profession, was a marked instance of the benefits of that temperance which he so ably defended and enjoined.

Historical composition always had a great attraction for Dr. Wood. In the two volumes of his Memoirs, Lectures and Addresses, published, the one in 1859, and the other in 1872, we find the following papers expressly of that character:

History of Materia Medica; History of Materia Medica in the United States; Sketch of the History of the Medical Department of the University of Pennsylvania; History of the Pennsylvania Hospital, delivered at the centennial celebration of its foundation, with a supplement to this, delivered at the laying, in 1856, of the corner-stone of the new Penna. Hospital for the Insane; and a *History of Christianity in India.*

The last named of these historical memoirs was part

of a larger plan of a *History of India*, conceived by its author in early life, and abandoned on account of the demands made upon his time by his professional duties. The eleven chapters which were completed make more than a hundred pages of the volume of Memoirs, &c., published by him in 1872. There is added, also, as a supplement, an Address on the British East India Empire, which was delivered by Professor Wood before the Athenian Institute of Philadelphia, January 23d, 1839. From the latter, we may take, as bearing upon a topic whose interest to the world at large is increasing every year, the following concluding reflections:

"But," it is there written, "the fortunes of India and Great Britain are not to be forever united. The English themselves, even those who have labored most assiduously in the consolidation of the Indian Empire, look forward to an ultimate separation. They look forward to the time, when, through the agency of causes brought to bear upon the people of India by their present political relations, they will have become enlightened, refined, elevated in sentiment and conduct; when the adoption of a pure religion will have cleansed away the moral foulness which now corrupts every spring of action; when their long union under one common government will have given them a feeling of political identity, a spirit of nationality and patriotism, which may lead them to desire independence, for which their expanded intelligence and purer morality shall have fitted them. When thus ripe for self-government,

may we not reasonably hope, that India will fall off spontaneously and peaceably from her long attachment, and, either as one or as several people, take her place in that brotherhood of nations, which, in America, in Africa, and in Australasia, will have owed their origin or civilization directly or indirectly to Great Britain, and will continue to revere the name and cherish the institutions of this mother of empires, when she herself shall have fallen into the decrepitude of age, or have gone to join her predecessors in the realms of history?"

A number of Biographical Memoirs, also, were written by Dr. Wood. We find, in his first volume, a memoir of Dr. Joseph Parrish, and one of Dr. Samuel George Morton; in the second volume, of Dr. Franklin Bache, of Frederick Beasley, D.D., and of Dr. James L. Fisher. All but one of these were prepared either for the American Philosophical Society, or for the College of Physicians, or the Medical Society of Philadelphia.

Of scientific contributions by Dr. Wood to the Proceedings of the American Philosophical Society, I find record of four. The first of these was delivered as an address to the Society, in 1860, his second year of service as its President, upon "Dangers of Hasty Generalization in Science." It exemplified, as well as inculcated, that cautious, although never timid spirit, which becomes the true philosopher; which welcomes the appearance of every promising novelty,

in science or in art, but always refuses to accept it simply because it is new; which believes everything which is proven by sufficient evidence, but nothing without evidence, whatever its attraction to the fancy, the intellect, or even the moral sense.

Dr. Wood's other papers, published in the Proceedings of this Society, were upon the subject of his observations and experiments, carried on through several years, upon his farm at Greenwich, in regard to the fertilizing and renewing action of the alkali potassa on the growth of fruit-trees, potatoes, wheat and other plants. The addition of wood ashes empirically to certain soils under cultivation, has long been a common practice in many places. By the chemical analysis of plants and of the earth in which they grow, as Dr. Wood mentions, their mutual physiological relations have, especially since the investigations of Liebig, been generally understood. But the merit of Dr. Wood's observations is, that they have furnished means of definite experimental demonstration, upon a considerable scale, of the practical application of this part of the chemical physiology of plants, in a manner productive of direct agricultural and horticultural profit.

Every inquiry of such a kind is, of course, of a complex nature, and the inferences derived from it must be properly collated and correlated with other facts and laws, which may qualify both their interpretation and their application. But the scientific and practical value of such investigations is beyond doubt; espe-

cially when carried on with the patience, carefulness and candor which attended those which have been thus briefly recorded.

Dr. Wood's professional eminence and personal qualifications led, naturally and suitably, to his being called to high official positions. In 1848, he was elected President of the College of Physicians of Philadelphia; an office which remained with him thereafter until his death. In 1855, he was made President of the American Medical Association; and in 1859, President of the American Philosophical Society. In this last position, he followed, after an interval of some years, Dr. Nathaniel Chapman. Both of these appointments may be regarded as not only altogether appropriate on account of the high individual merits of those who received them, but, also, as evincing a recognition of the relation of the medical profession to the general advancement of science, to which medical men here, as elsewhere, have rendered such large and numerous contributions; besides exemplifying, in their own vocation, the principle that science lives and works most fitly, not for its own intellectual aims alone, but also for the common benefit of humanity.

In 1870, Dr. Wood was disposed to retire from all official duties, on account of his advancing age and infirmity. On the occasion of his tendering his resignation of the Presidency of the American Philosophical Society, its Secretaries were authorized, as a committee, to request its withdrawal. In the communication

addressed to him in regard to it by them, he was assured on behalf of the members of the Society, that all continued to recognize him as "the most worthy representative it could have, not only where it holds its meetings, but in its correspondence with other learned bodies like itself."

After his retirement from active service in the Chair of Theory and Practice of Medicine in the University of Pennsylvania, he was made Emeritus Professor. He became also, soon afterwards, a member of the Board of Trustees of the University. In that Board, as Chairman of its Committee on the Medical Department, he exercised for many years an influence upon its affairs more important, perhaps, than that of any other individual member.

His distinctions were not confined to his own city. The College of New Jersey bestowed upon him the degree of LL.D. Besides being made honorary or corresponding member of the New York Academy of Medicine, and the Medical Societies of Massachusetts and Rhode Island, the same honor was conferred upon him by the *Société de Pharmacie* of Paris, the *Medico-Chirurgical Society* of Edinburgh, the *Royal College of Physicians* of Dublin; the *Silesian Society for Native Culture* of Breslau, *L'Academia de' Quiriti* of Rome, and the *Societas Cæsarea Naturæ Curiosorum* of Moscow, Russia. He attended, as a guest, two meetings of the British Association for the Advancement of Science, in 1848 and 1861. In the

former year, he was appointed delegate from the American Medical Association to the meeting, at Bath, of the British Medical Association. At his reception on this occasion, when his credentials were read, complimentary resolutions were passed, and the whole assembly rose to greet him, as the accredited and honored representative of his profession in America. During his last visit to England, in 1861, appropriate official and social courtesies were extended to him, as President of the American Philosophical Society, and of the College of Physicians of Philadelphia, by the officers and members of the Royal Society, and of the College of Surgeons and Physicians in London.

Three journeys to Europe were made by Dr. Wood, in 1848, 1853, and 1860-61-62. He visited in turn nearly all the principal countries of Europe, including Russia. Nor were these, to him, tours only of idle amusement or mere recreation. His natural and acquired industry, his real love of work as well as of knowledge, induced him to study carefully, sometimes almost exhaustively, every place and object of interest. Many volumes of his Journals of Travels have been preserved. They are very systematically written, and contain more valuable information, clearly and tersely conveyed, than most popular books by famous voyagers. A scientific note book was also kept by him, upon some particular subjects of interest and importance. Full, often elaborately detailed accounts

of his observations are given, of the most varied things and places; as, for example, the Museum of Northern Antiquities at Copenhagen, to the description of whose contents he gives fifteen letter-size pages of his Journal; the geological structure and indications of the banks of the Tiber; art galleries and the carnival in Rome; vineyards and vine culture near Perugia, on the way from Rome to Florence; the Lariborsière Hospital at Paris; the great International Exhibition at London; the reception of a deputation of philanthropists by Lord Palmerston; and the annual dinner of the British Medical Association. One of the pleasing minor incidents of his last visit to London, was the refusal of the proprietor of a leading drug establishment in that city to receive payment from him for some rather expensive medicines, on account of the services rendered to himself by Dr. Wood in his writings.

Some important concerns of the American Philosophical Society received careful and judicious attention from him during his journeys abroad. Among these were, his promotion, by personal address and correspondence with our Minister at St. Petersburg, of the donation to the Society of one of the copies of the reprint, authorized by the Emperor of Russia, of the Sinaitic Codex of the New Testament, brought to Europe by Professor Tischendorf. While in Paris, also, he found it necessary to devote some time to the affair of the Michaux legacy to this Society; which was then complicated by the reluctance of Madame Beziers,

widow of Michaux, to carry out, as desired, some of the required arrangements.

Our great civil war was going on during the last absence of Dr. Wood in Europe. Every mail brought news of battles, sometimes with reverses and sometimes successes, of the Union arms. So patriotic a man could not fail to be much moved by these events; and his Journal has many pages filled with reflections upon them, and the expression of his anxious solicitude for his country during its perils. There is interest in these expressions, as those of a sagacious man, looking forward as well as backward, at the career of this great Republic, then passing through its ordeal of fire. In 1861, he was, with others, much exercised about the possibility, at one time threatening, of Great Britain interfering to the advantage of the Secessionists. He predicts as the result of such an unwarranted action, certain disaster, if not ruin, to England; through advantage being taken by France, under Napoleon III., of the opportunity thus afforded to provoke new conflicts, not improbably ending in a general European war.

Confidently anticipating, at the beginning of 1862, the final, if not speedy triumph of the forces of the Union, he saw very distinctly at that period, the later prospect, which he indicated in these words: "But the problem appears to me much more difficult, what is to be done with the South when conquered, than will be the task of conquest." The plan which he favored

was one which many others have approved; perhaps more even now than at the close of the war, since the trial of a different but imperfectly successful policy; namely, "the establishment, in the States which had forfeited their rights under the Constitution, of provisional governments, with officers appointed by the President and Senate, and under regulations prescribed by Congress, until, by a gradual amendment in the character or material of the population they shall be again fitted to govern themselves as constituent parts of the Union."

Another, and still nearer, cause of anxiety began, early in the same year, to throw, as he wrote in his Journal, a deep shadow over Dr. Wood's future. This was the discovery that a cancerous tumor was beginning to threaten his wife's health and life. His plans of travel were altered in consequence. A voyage to Athens, Constantinople and Egypt was given up; and after some farther stay in Italy, the party traveled slowly toward Paris.

There, after careful surgical consultation, in April, 1862, the operation of excision was skilfully performed by the veteran surgeon, Velpeau, assisted by Nélaton, and Dr. Beylard, then of Paris, but formerly of Philadelphia. Dr. Wood's feeling upon the subject of his wife's illness and suffering was expressed thus in his Journal: "She and my country are the objects nearest my heart; and, if I know myself, I would willingly give up my own life, could I thereby secure the continued

enjoyment of life and happiness to either." Her life was prolonged, with tolerable health for a considerable period, until 1865.

Before Dr. Wood's embarkation upon his last journey abroad, in 1860, a farewell public dinner was given him by the members of the medical profession in Philadelphia, in testimony of their high respect, esteem and affection. The venerable and distinguished Dr. La Roche presided. The occasion was one of unusual interest. No physician in Philadelphia was ever more, if ever one so much, looked up to by those of all ranks and ages, as truly the head, the patriarch* of the medical profession in America.

At the time of his death, in 1879, Dr. Wood was a few days more than eighty-two years of age. On the subject of his funeral, I must cite the words of Dr. Littell, in his memoir, already mentioned: "His remains, followed by a long train of sorrowing friends, were silently interred at Laurel Hill, as the manner of Friends is to bury.† Not a word was uttered, not a note was heard, either at the house or at the grave. All instinctively felt that fulsome panegyric or trite remark would be alike out of place on such an occasion. They came 'to bury Cæsar, not to praise him.' But

*This expression was applied by Dr. Wood himself, in 1850, to his predecessor, Dr. Nathaniel Chapman. It may be said to be still preserved to Philadelphia, in the person of our distinguished surgeon, Professor S. D. Gross, who has received the very highest honors on both sides of the Atlantic.

† It need scarcely, perhaps, be here noted, that fitting discourse, by ministers or others, is frequent, although not universal, at the funerals of "Friends."

though no religious rite was observed or comforting service performed, those who were present felt none the less deeply that the object of their love and veneration—the Christian gentleman, the representative of [illegible], the knight of stainless record—had been gathered to his fathers after a well-spent life [illegible] years and honors, in the confidence of a certain faith, in the comfort of a reasonable, religious and holy hope, in favor with God, and in perfect charity with the world."

In person, Dr. [illegible] was rather tall until the last few years of his life, slender and very erect in carriage. His features were regular though not striking. He wore [illegible] and no beard. He was always dressed in black, and very neatly. His manners were dignified and formal, his whole appearance grave and sedate. To strangers, and those of slight acquaintance, he seemed rather to repel approach, and to produce a feeling of constraint. Amongst intimate friends, [illegible] in social intercourse this severity was relaxed, so that although never demonstrative he was quite affable and, at times, genial. As Dr. Packard describes him in his [illegible] sermon,[illegible] "whoever [illegible] to know him found in him a faithful friend, a [illegible] and a true man." His uniform [illegible] was at the [illegible] "the [illegible] the words of [illegible]

[illegible]

Dr. Littell, "his purity was that of the snow
no one in his presence ever ventured to
ribald jest or unseemly remark." But
know him, in a long acquaintance, to be fo
off his guard, in the measured dignity of hi
and then it was under somewhat unusual
It seemed not improbable, however, that he
ly an imperious temper; kept, upon prin
admirable control.

His conversation was agreeable and o
structive, though not brilliant. In one res
extremely different from Dr. Nathaniel Cha
only, in very frequent professional and
course, did I hear him utter a facetious r
then, it was rather the dry wit which bri
than the humor which compels laughter.

One of Dr. Wood's early formed habits
mon, perhaps, with toilsome authors, was t
most of his literary work late at night.
o'clock until two, three or four in the morn
usual hours for such employment. So in
this become, as a "second nature" with hi
in advanced age he laid his pen almost e
he found it impossible to return to ordinar
was still obliged, almost to the last, to tu
day, and day into the time of his repose.

Open-handed benevolence was a ma
Dr. Wood's character. Privately, and to
tutions, he gave largely, although always

discrimination and judgment. The University of Pennsylvania, the Pennsylvania Hospital, the Philadelphia College of Physicians, the American Philosophical Society and the Academy of Natural Sciences were the main recipients of his liberal donations during his lifetime; and several of these institutions also became principal legatees in his will.

Nor ought it to abate our appreciation of this munificent liberality, that, since his decease, the expected pecuniary value of these legacies has not been fully met, on account of the depreciation of securities,* and the inability of his cranberry plantation in New Jersey as yet to realize the large profits which he anticipated from it.

This last project, it appears needful to believe, was probably the least fortunate of Dr. Wood's undertakings. So sanguine, however, was he in regard to it, that he added for its extension a large number of acres to his farm at Greenwich, at prices larger than their owners, his neighbors, thought fit to ask of him. Here, as usual, mercenary aims were the farthest from his thoughts.

Mention has been before made, incidentally, of Dr. Wood's inclination towards a certain stateliness in his mode of living. In traveling during the summer through the State of Pennsylvania, and even in going

*His will was made in 1871, when gold was at a premium of 12½ per cent., and all other kinds of property were at a correspondingly high, if not higher range of prices, compared to those following the resumption of specie payments, and especially the depression which succeeded the "panic" of 1873.

to his farm in New Jersey, he would not unfrequently drive four-in-hand. This did not appear to be at all from affectation or love of display, for which he had no fondness; but rather from his conception of what belonged to his position in the profession and in general society, of which he was so prominent a member.

In all things, correctness, exactitude, method, and thoroughness were leading aims with Dr. Wood. These were shown above all other traits in his courses of instruction, private and public. No pains were spared to make every lecture complete, even in its smallest *minutiæ*. His manner as a lecturer was comparatively quiet, but sufficiently energetic; with enough animation always to secure attention, although never in the least approaching rhetorical excess. Others might easily obtain more admiration for their eloquence; no lecturer in the University was ever more effective, in conveying instruction and information to his classes. Especially in the abundance and excellence of the illustrations accompanying his lectures, he was in advance of almost all his contemporaries.*

In Dr. Wood's style as a writer, the same qualities of clearness and correctness were constantly manifested. If to any author, in science, philosophy, forensic or general literature, the term *faultless* may be applied, it may be to him. Nor was his manner correct

*If there was an exception to this, it was in the case of Professor Robert Hare. But he, as is well known, though a very illustrious chemist, and abounding in skilful and expensive experimentation, was not a superior lecturer.

merely; it was both elegant and forcible; varied without eccentricity, and polished, although devoid of ornament. His anniversary discourses on public occasions connected with the Pennsylvania Hospital, and his introductory and other addresses at the University, were models of their kind; and there are passages in his History of Christianity in India, which, without any of the brilliant adornments of a Macaulay, would not seem, in their manner, out of place upon the pages of a Bancroft or a Prescott.

His youthful ventures into the realm of poetic authorship have been already mentioned. The exact date of the composition of his longest versified work is not known to me. The copy which I possess was printed in Philadelphia, in 1864, without its author's name. It was dedicated to his wife, in language of admiration and tenderness; as the one who, as he therein says, "hast taught me how much a woman can love, and hast enabled me, through the feelings thou hast inspired, to measure the depth of affection of which the manly heart is capable."

This poem was an epic, in rhymed heroic verse, entitled, "First and Last; a Poem intended to illustrate the ways of God to man." It is divided into eighteen chapters (instead of books or cantos), making a 12mo volume of more than two hundred and fifty pages.

In reading it, one might easily forget that its author was a man of practical mundane experience and cyclopædic research, an authority in precise and applied

science. It is not without evidence of some power of imagination. Scarcely a false rhyme or incorrect measure, or even a harsh sounding line, occurs throughout. Yet it is almost equally without a spark of poetic genius. The "*mens divinior*," the Olympic gift, which comes not with any toil and is created by no strongest force of will, is wanting. Many scientists, like Sir Humphry Davy, have begun life with poetic aspirations; but no born poet, except Goethe, ever contributed important and permanent original gifts to science.* Still less, perhaps, ought we to look for the fire of genius where the whole character of a man's productions is that of great accumulation rather than of creation. Let us, then, without further criticism, accept on behalf of this epic, whose subject was the Miltonic one of the Fall of Man, and the scenes that followed it during the life-time of Adam and Eve, some of Dr. Wood's own earlier lines, written in the album of a friend, in 1831:

"What tho' no fire celestial glows
  Along the burning line;
Nor stream of sweetest music flows,
  Nor gems of fancy shine;

"And even should my hand untaught
  Fail from the string to wrest
A note responsive to the thought
  That dwells within my breast;

*The scientific mind has been more often associated with artistic than with poetic genius; as, very remarkably, in the case of Leonardo da Vinci. In our own times, Charles Kingsley and O. W. Holmes have been the most notable instances of the combination of attainments in science with great literary success.

"Yet partial friendship to these lays
Will not her ear refuse;
And, if she cannot justly praise,
Will labour to excuse."

Dr. Wood embodied in this epic poem his calm and deeply assured conviction of the truth and supreme importance of the Christian religion, which underlaid and supported the whole structure of his life.

A few lines from "First and Last" may suffice to set this forth:

"Lo! from the cross on which the Sinless died,
How streams the light of life on every side!
How penetrate remotest realms its rays,
Earth's darkest corners kindling into blaze!
To every land the messengers of love,
The Lord's elect, commissioned from above,
Bear the glad tidings; everywhere they sow
The seeds of truth, which, spirit-nurtured, grow
To a rich harvest. From each center spreads
The faith thus planted.

"Yet, now this, now that
Prevails. But of the two does victory wait
Most frequently on good. By slow degrees
Faith spreads her conquests. Over lands and seas
Is borne the banner onward, till at last
All nations bow before it."

Few men, of positive belief and devout feeling, make so little outward profession of religion as did Dr. Wood. But this is not difficult to account for. Not only was he a man of much natural reserve, especially in regard to the most sacred emotions of his heart, but this disposition was promoted by circumstances. Born into membership with the Society of Friends, and

educated mainly under its influences, his formal connection with it was severed by his marriage, his wife belonging to the Lutheran communion. He joined no other body. Often attending the meetings of Friends, and also not unfrequently accompanying his wife to her chosen place of worship, his religion was altogether unsectarian; but, for that, none the less real. His Journals, as well as his unprofessional published writings, manifest this clearly and often; and it was well understood by those who had the privilege of confidential intercourse with him. On one occasion, he expressed to a near relative his opinion, that the doctrine of the Society of Friends, of the immediate and perceptible guidance and teaching of the Holy Spirit (acknowledged, indeed, in some manner, by other denominations, but held most definitely and strongly by them) affords the only *scientific* basis for religious belief; since it gives to the historical revelation contained in the Scriptures a confirmation exactly corresponding to that *verification by experiment* which is the characteristic of modern science, since its improvement by means of the Baconian inductive philosophy.

But we must hasten towards our conclusion. To Dr. Wood, better than to most men, might be applied the poet's line: *Justum et tenacem propositi virum.*

If he had genius, it was a *genius for work*; a rare capacity for continued, indomitable, all-conquering labor. With this, he became an eminently successful man. As he wrote of Dr. Chapman,* "His career

* Lectures and Addresses, 1st Vol. p. 211.

throughout, from youth to manhood, from manhood to old age, has been in the highest degree prosperous and flattering; if the most kindly regards, general respect, a wide social and professional influence, a reputation limited only by the bounds of civilization, and the highest positions not political which an individual can attain in this country, may be considered as evincive of prosperity and honour."

In his own words, also, addressed, in 1853, to a class of medical students, we may set forth the noble motives which animated his life:

"Do not live solely for yourself. Do not seek wealth, station, influence, merely for your own personal gratification; but consider them as means for doing good, for spreading benefits around you, and for making an impression on the world, which, when you are gone to your rewards, will cause grateful recollections to cluster about your memory, and your example to be held up to the young for imitation in all future time."

So taught, and so lived, he whom, in the full ripening of his days, we have now lost. Truly he was a philosopher, in the old, first meaning of the word: a lover, acquirer and promoter of wisdom; and, with this, of goodness also. May his memory, and the influence of his example, never pass away from amongst us!

Stated Meeting, October 15, 1880.

Present, 12 members.

President, Mr. FRALEY, in the Chair.

Letters of envoy were received from the Botanical Garden at St. Petersburg, and the Meteorological Office in London.

Donations for the Library were received from the Botanical Garden at St. Petersburg, the Zoölogischer Anzeiger, Prof. Otto Schmidt of Strasbourgh; the Geographical Societies of Paris and Bordeaux; Revue Politique; London Nature; Chemists' Journal; Canadian Naturalist; Essex Institute; Harvard College Library; American Antiquarian Society; American Journal of Science; Franklin Institute; American Journals of the Medical Sciences, and of Pharmacy; Mr. Russell Thayer; the U. S. Coast Survey; Cincinnati Society of Natural History, and the Ministerio de Fomento of Mexico.

A report of the Committee on the Magellanic Prize essay was called for.

The death of Prof. Benjamin Pierce, at Cambridge, Oct. 6, aged 71, was announced by the Secretary, who read a notice of the deceased from the pen of Thos. Hill, late President of Harvard College.

Dr. Seidensticker described an amusing specimen of English poetry, which was read by the Secretary at his request; a dedication to the Chancellor of the University at Lund, and Senator of the Kingdom of Sweden, the most honorable Lord Count Charles Gyllenborg, *Dissertatio Gradualis de Plantatione Ecclesiæ Svecanæ in America*, by Tobias Er. Biörck, Americano-Dalekarleus. Upsalæ Literis Wernerianis, A. D. 1700.

Mr. Lesley drew attention to Dr. P. J. J. Valentini's very satisfactory investigation of the probable fabrication of Landa's Mayan alphabet just published in the Proceedings of the American Antiquarian Society (No. 75, page 59 *et*

seq.), with the figures of the Landa text and from other sources.

Mr. Lesley said that so careful and precise a train of argument has seldom been pursued in a difficult case of Philology in dispute, and Dr. Valentini's conclusion will probably be generally accepted that Bishop Landa obtained from his catechumens the best figures which their imaginations suggested to them at the time for representing the vowels and consonants as he pronounced these before them; therefore, that his list of so-called alphabetic figures, being more or less the invention of the occasion, had no scientific or historic value then, and cannot now be used for deciphering Mayan or Mexican picture-writing in an alphabetic sense.

But had Dr. Valentini compared Landa's figures with those of Egypt, he would have been surprised at certain resemblances of a remarkably radical character; although these probably would not have led him to abandon his train of argument; as the resemblances cannot be considered sufficiently valid to oblige us to a different conclusion.

It is nevertheless astonishing to notice that while Landa's *first* B is, according to Valentini, represented by a foot-print, and that *path* and *foot-print* are pronounced *Be* in the Maya dictionary, the Egyptian sign for B was the human leg.

Still more surpising is it that the H of Landa's alphabet is a tie of cord; while the Egyptian H is a twisted cord. What connection can there be between a cord and the aspirate? Dr. Valentini explains, that in the Dresden codex a doubled-up rope frequently occurs, and that *tying-up days* to form a year was a common Mexican chronological expression. *Haab* is Mayan for *year*; and Valentini thinks that the rope symbol for *year* was given to Landa as the best letter *Ha* which his pupils could invent for him on the spur of the moment.

But the most striking coincidence of all occurs in the coiled or curled line representing Landa's U; for it is absolutely identical with the Egyptian curled U. The Mayan word for *to wind* or bend is *Uuc;* and that fact satisfies Dr. Valentini; but why should Egyptians, confined as they were to the Valley of the Nile, and abhorring as they did the sea and sailors, write their U precisely like Landa's alphabetic U in Central America? Birch gives *ha-ti* as the name of the Egyptian coiled U and of *the tow-line of a boat.*

There is one other remarkable conincidence between Landa's and the Egyptian alphabets; and by the way, the English and other Teutonic dialects have a curious share in it. Landa's D (T) is a disc with lines inside the four quarters, the allowed Mexican symbol for *day* or *sun*. So far as the sound is concerned the English *day* represents it; so far as the form is concerned the Egyptian "cake" ideograph for (1) *country*, and (2) *the sun's orbit*, is essentially the same. The Egyptian name of the latter is read *sen-nu*. Brugsch gives *S'en* as *circumference*, perifery, the turn of the shadow, *S'ennu* the entourage of a person, *S'na* to make return, all of them with the circle as a determinative.

Mr. Lesley described the results of a recent visit to Saltville, in Virginia, made by Mr. Henry Carvil Lewis, of Germantown, on the suggestion that Tertiary shells might be found at the eastern corner of the little plain on which the salt and gypsum works stand.

Mr. Lewis reported that he had not only carefully collected all the univalves and bivalves of the locality but submitted them for examination to Mr. Tryon, of the Academy of Natural Sciences, who pronounced them all recent, and one of them as a species nowhere yet seen except in the Houston river, which flows along side of the plain, and the waters of which communicate with the wells, as described by Mr. Lesley some years ago.

Mr. Lewis had made a comparative collection of the same shells from the banks of the Houston and found the two suits identical.

On causing a number of pits to be dug he was surprised to find the surface stratum (three feet deep) to be a layer of these shells, most of the *unios*, &c., broken, but the gasteropods whole, mixed with pottery and embers. It is evidently a *kitchen trash deposit.* The shells did not extend beyond the area of the pottery. The Indians broke up the univalves to mix with the clay of the pottery, but the gasteropods must have been used only for culinary purposes.

He found under the layer of shells and pottery a layer of *local drift clay*, several feet thick, resting on the red gypsum salt muds, which are several hundred feet deep and occupy a basin a mile wide, eroded along an anticlinal arch of Lower Silurian limestones, the outcrops of which form the hill walls of the little enclosed secluded valley. The rocks dip 20° to 30° south-east; and from 50° to 60° north-westward towards the Houston river, outside of the enclosure. This erosion must have commenced when the Appalachian continent, crowned by Permian deposits, rose from the sea on the first construction of the anticlinal and synclinal folds. The salt clays then are probably of Trias age. That the gypsum is the result of the decomposition of the limestone layers is plainly shown in the shaft and tunnel workings; and it is confined to the walls of the basin, against which the horizontal salt-muds lie nonconformably.

Mr. Lesley embraced this occasion to make some remarks in opposition to the conclusions of Prof. Stevenson, expressed in his valuable Notes on South Virginia, read before this Society, Aug. 20, respecting the comparatively recent date of the great Virginia faults.

Prof. Stevenson does not positively assert that the faulting has succeeded the flexing by a longer or shorter interval of geological time, but he says: "It seems not wholly improbable that the faults are of later date than the disturbance which produced the comparatively gentle synclinal between

Walden's ridge and the Clinch river;" and the whole tone of his concluding paragraphs leaves the impression that he assigns the Appalachian flexing to one age and the faults to another and later age. This would be in accordance with his opinions respecting the Pennsylvania anticlinals as preceding some of the coal deposits, published in his Reports of Progress KK and KKK of the Second Geological Survey of Pennsylvania.

Mr. Lesley said that his long study of the Coal Measures of the United States led him to entertain grave doubts of this. In fact he has repeatedly [illegible] the regular and remarkably regular increase in the [illegible] of the [illegible] towards the east, over the very large [illegible] in Ohio outcrops and in Maryland and Eastern [illegible] as sufficient evidence that the Appalachian [illegible] up to the close of the Coal era.

[illegible] of the faults of Virginia and Tennessee in connection with the [illegible] anticlinals of Pennsylvania [illegible] in like manner [illegible] producing essentially the same [illegible] the same age.

[illegible] the probability of [illegible] date for the faults in [illegible] Southern Virginia.

[illegible]

in America, and by a member of this Society, and published in its Proceedings. He remarked on (1) the extreme sensitiveness of the plate, and (2) on the extraordinary perfection of the running machinery of the driving clock, which was required to hold the image steadily upon the plate for fifty minutes, ten minutes being hitherto considered the maximum.

The letter is as follows:—

271 MADISON AVENUE, NEW YORK,
October 9th, 1880.

MY DEAR BARKER :—

I have succeeded in photographing the nebula in Orion. It took an exposure of fifty minutes which, as you can well imagine, was a hard test for the driving clock. This is the first time a nebula has been photographed. I used the new Clark triple objective of 11 inches aperture, mounted on the equatorial stand I made some years ago. This objective is especially corrected for the photographic rays.

The pictures show the mottled appearance of the bright portion of the nebula admirably. It will take some time to discuss the pictures taken since Sept. 30th, as comparisons must be made with the drawings of Lord Rosse, Bond and others.

The importance of the result turns on the fact that photographs will show with certainty any changes in the nebula and perhaps enable us to determine some of the laws ruling these elementary forms of matter. They may indicate the process of the genesis of solar systems.

If it suits your convenience will you call the attention of the Philosophical Society to this matter, and oblige

Yours truly,
HENRY DRAPER.

Pending nominations Nos. 904, 909 to 920 were read.

Mr. Price reported in behalf of the Committee that a discourse on the life and character of the late President of the Society, George B. Wood, M.D., LL.D., was delivered by Dr. Henry Hartshorne, in the hall of the College of Surgeons, on the 11th instant, and asked that 1000 extra copies be printed for circulation, which was so ordered; and the thanks of the Society presented to the College for the free use of its room.

On motion it was resolved that the Curators be authorized to permit a copy to be made of Martin's portrait of Franklin.

The ballot boxes being examined by the presiding officer,

the following persons were declared duly elected members of the Society.

Mr. Alvan Clark, of Cambridgeport, Mass.
Mr. Alex. E. Outerbridge, of the U. S Mint.
Mr. Jacob B. Eckfeldt, of the U. S. Mint.
Mr. Patterson Dubois, of the U. S. Mint.
Mr. Lewis A. Scott, of Philadelphia.
Mr. Cadwalader Biddle, of Philadelphia.
Mr. Thos. H. Dudley, of Camden, N. J.
Mr. Isaac C. Martindale, of Camden, N. J.
Prof. Wm. Boyd Dawkins, of Manchester, Eng.
Dr. Daniel Draper, Ph.D., of New York City.

And the meeting was adjourned.

Stated Meeting, Nov. 5, 1880.

Present, 11 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Mr. Alexander E. Outerbridge, Jr., dated U. S. Mint, Oct. 26; Mr. Jacob B. Eckfeldt, dated U. S. Mint, Oct. 28; Mr. Patterson Dubois, dated U. S. Mint, Oct. 19; Mr. Lewis A. Scott, dated 1806 Locust street, Philadelphia, Oct. 19; Mr. Cadwalader Biddle, dated 1420 Walnut street, Philadelphia, Nov. 4; Mr. Isaac C. Martindale, dated Camden, N. J., Oct. 10; Prof. Wm. Boyd Dawkins, dated Boston, Mass., Oct. 21; and Dr. Daniel Draper, dated Meteorological Observatory, Central Park, N. Y., Oct. 19.

Letters of acknowledgment were received from the Société Royale, Upsal (99-103 inclusive; List of Members, and Catalogue, Part III); Société Hollandaise, Harlem (104); K. B. Akademie, Munich (102, 103); Naturforchende Gesellschaft, Freiburg in Baden (102, 103); Société des Sciences Physiques et Naturelles, Bordeaux (96, 98–104 inclusive); and the Royal Society, Edinburgh (105).

Letters of envoy were received from the Société Royale, Upsal, dated Nov. 1879; Fondation Teyler, and the Société Hollandaise, Mai, 1880. Harlem; Physicalische Gesellschaft, Berlin, July 20; Schweizerische Gesellschaft, Bern; Royal Irish Academy, Dublin, Aug. 1880; and the Department of the Interior, Washington, Oct. 27, 1880.

A letter of envoy containing a request for exchange of publications was received from the Société Zoologique et Botanique de Finlande, dated Helsingfors, June, 1880.

On motion the name of this Society was placed on the List of Correspondents to receive the Proceedings.

Donations for the Library were received from the Academies at St. Petersburg, Munich, Philadelphia and St. Louis; the Observatories at St. Petersburg, Upsal, Vienna, Munich and Turin; the Royal Society, Upsal; k.k. Geologischer Reichsanstalt, k.k. Geographische Gesellschaft, and Anthropologische Gesellschaft, Vienna; Geologische Gesellschaft, Berlin; Herrn F. Sandberger; Editors of the Fortschritte der Physic, Berlin, and the Zoologischer Anzeiger, Leipsig; Societies at Ulm, Bremen, Bern, Freiburg i B., the Hague, Harlem and Lille; Museum Teyler, Harlem; Société d'Anthropologie, Ecole Polytechnique and Revue Politique, Paris; Société de Géographie Commerciale, and Société des Sciences Physiques et Naturelles, Bordeaux; Royal Geographical Society, Geological Society, Zoological Society, Nature, and the Chemists' Journal, London; Natural History Society, and Mr. Samuel H. Scudder, Boston; Museum of Comparative Zoology, Cambridge; R. I. Historical Society, Providence; American Journal, New Haven; Mr. Isaac C. Martindale, Camden, N. J.; Medical News, Journal of Pharmacy, Mr. Henry Carvill Lewis, and Mr. Henry Phillips, Jr., Philadelphia; U. S. Department of the Interior, Washington; American Antiquaries, Chicago; Oriental and Biblical Journal, Clinton; National Museum, and Ministerio de Fomento, Mexico; and the Société Zoologique et Botanique de Finlande, Helsingfors.

The Committee to whom was referred the consideration

of the claim for the Magellanic Premium presented a report, which was ordered to lie over for consideration at the first stated meeting in December next.

An obituary notice of the late Dr. John Neill, prepared by Dr. Brinton at the request of the Society, was read by Dr. Horn.

The death of Mr. Peter McCall, a member of the Society, at Overbrook, Oct. 30, in his 73d year, was announced by Mr. Henry Phillips, Jr., who, on motion of Mr. E. K. Price, was appointed to prepare a notice of the deceased.

Dr. Horn presented two communications for publication in the Proceedings:

1. Critical notes on the species of *Selenophorus* of the United States.

2. A review of the species *Anisodactylus* inhabiting the United States.

Mr. Chase offered a list of his papers published by the Society.

Mr. Lesley exhibited some recently executed works of the Geological Survey:

1. A printed sheet of oil well sections and profile colored to show the thinning away of the Catskill formation, &c., north-westward along the valley of the West Branch Susquehanna river, above Lock Haven, by Mr H. M. Chance;

2. A hand-colored printed map of the Philadelphia belt, by Mr. C. E. Hall;

3. A MS. map of part of the Mahanoy and Shenandoah anthracite basins in Schuylkill county, showing the structure of the Mammoth bed by contour lines, by Mr. Chas. A. Ashburner and Mr. Arthur Sheafer.

Pending nominations Nos. 909, 920, and new nominations Nos. 921, 922 were read.

Mr. Fraley reported that he had received and paid over to the Treasurer, $131.28, being the last quarterly payment on the Michaux Legacy, due Oct. 1, 1880.

Mr. Fraley informed the Society that a petition for a new transcription, called for by the French Minister of Finance, had been duly executed and forwarded to Paris, and that

the Minister of Finance had authorized a new transcription on the books of the office at Paris.

Mr. Briggs addressed the Society, urging some action for applying the Magellanic funds to the rewarding of discoverers and inventors who did not apply for the premium.

Mr. Fraley thereupon gave a short history of the original bequest, the accumulation of the extra fund, the legal opinion of Mr. Horace Binney respecting its use, its application by the Society to publication, the establishment of the extra-Magellanic premium, the publication of other premiums, and the appointment of a committee on premiums at large.

On motion it was

Resolved, That the Board of Officers and Members in Council be requested to take into consideration the present regulations in regard to the award of the Magellanic Premium, and to report, if they may deem any change expedient, such modifications as may lead to the awarding of said Premium for objects of scientific discovery mentioned in the original donation.

And the meeting was adjourned.

Obituary Notice of Dr. John Neill. By Dr. Brinton.

(*Read before the American Philosophical Society, Nov. 5, 1880.*)

Among the numerous surgeons of distinction who have given lustre to medical science in Philadelphia, the late Dr. Neill deservedly stood in the front rank. He came of a race of physicians, his father and both his paternal and maternal grandfathers having been members of that profession. He was born in Philadelphia, July 9th, 1819, and received both his academic and medical degrees from the University of Pennsylvania, the latter in 1837. The whole of his subsequent life was passed in this city, where he soon acquired large surgical and general practice. At various periods he occupied prominent positions in relationship to his profession. It will be sufficient to mention the leading ones of these. As early as 1845 he was appointed Demonstrator of Anatomy in the University of Pennsylvania, and thirty years later, Professor of Clinical Surgery in the same institution. For several years after 1864, he was Professor of General Surgery in the medical department of Pennsylvania College, an educational organization not now in existence. At various epochs he was surgeon to the Pennsylvania Hospital, to the Philadelphia Hospital, to Wills Hospital, and Consulting Surgeon to the Presbyterian Hospital.

During the war of the Rebellion, especially in its earlier years, he was actively engaged in rendering professional services to the wounded soldiery.

In the summer of 1861 he was appointed by the General Government to establish army hospitals in this city, and the first eight organized and constructed here were put in working order under his supervision. At the height of the conflict, when the Southern forces invaded this State, he was appointed Medical Director of the militia and emergency troops of the State. In fulfilling the duties of this office, he was at Gettysburg after the battle, taking care of the wounded, and established a hospital at Carlisle, and also those at Hagerstown, Md.

Dr. Neill was a writer as well as a practitioner. His contributions to literature were principally, if not exclusively, confined to subjects relating to medical and surgical science, and were usually in the form of articles in medical periodicals. He is known as the author of several anatomical works treating of the arteries, veins and nerves, and also of the surgical and anatomical portions of a very popular work for students, entitled "A Compendium of Medical Science," published about twenty-five years ago.

A Review of the Species of ANISODACTYLUS *inhabiting the United States.* *By George H. Horn, M.D.*

(Read before the American Philosophical Society, Nov. 5, 1880.)

It is difficult to understand why this genus has passed almost entirely neglected, and why so much confusion and consequent synonymy prevail, when a short study will demonstrate how easily the species may be grouped and each separated from the other by sharply defined structural characters.

The division of the genus into three subgenera by the form of the anterior tibial spur is long known, but the characters which follow seem for the most part to have entirely escaped notice. The first of these, taken from the structure of the posterior tarsus, and the length of the first joint as compared with the next two, needs no further explanation.

The presence of two or one setigerous puncture on each side of the clypeus near the anterior margin is a character of very great importance and may be used elsewhere in the Carabidæ in the separation of smaller groups of species in the manner indicated in the accompanying table.

The structure of the underside of the male tarsi is also very useful here, it affords a means of supplementing any character which may be drawn from the two sexes together, separating very sharply species which appear superficially closely allied.

In the *dilatatus* and *sericeus* groups I have been unable to distinguish any true dorsal puncture. In all the other species the dorsal puncture is distinct and will be found at the posterior third of the elytra on or very close to the second stria.

All the species have the spurs of the posterior tibiæ slender and rather

long, in one, however (*immanis*), the spurs are apparently more closely approximated at base, and are broad, slightly foliaceous at the sides and obtuse at tip.

Characters of minor importance will be found under the various group headings.

Having, by means of the characters above indicated, approximated those hitherto recognized species which seemed closely related, numerous forms have been found which have refused to be separated, especially near *rusticus* and *porosus*. I have accordingly placed these as synonyms, and in defence of that course will state, that the mass of material which I have had before me from my own and Dr. LeConte's cabinet fully warrants such a procedure.

In the bibliography, which will be found at the end of the paper, I have marked those species with an asterisk (*) of which I have seen types or specimens compared directly therewith.

The following is the table of groups:

Terminal spur of anterior tibiæ trifid.................................A.
Terminal spur of anterior tibiæ dilated at middle.....................B.
Terminal spur of anterior tibiæ slender...............................C.

A. Posterior tarsi slightly flattened, shorter than the tibiæ, the first joint very little longer than the second. Hairy species..............A—a
Posterior tarsi slender, as long as the tibiæ, the first joint nearly as long as the next two together. Glabrous species..................A—b

B. Posterior tarsi slender, equal to the tibiæ, first joint long; first joint of middle tarsus ♂ pubescent at tip. Black species...............B—a
Posterior tarsi flattened, first joint short; first joint of middle tarsus ♂ glabrous beneath. Species bi-colored or metallic.............B—b

C. Elytra with distinct dorsal puncture, first joint of middle tarsus ♂ glabrous beneath or with a very small pubescent space. Elytra smooth, surface more or less metallic.......................................C—a
Elytra without dorsal puncture, first joint of middle tarsus ♂ pubescent over half its surface. Elytra densely punctulate, surface black, sub-opaque, and finely pubescent..................................C—b

Group A—a is peculiar to the Pacific region, C—b to the Atlantic, the other groups contain species from both sides of the continent.

A—a has been called *Dichirus;* A—b, *Triplectrus;* B—a, B—b, *Anisodactylus;* C—a, *Haplocentrus.*

A—a, *dilatatus* Group.

Species more or less hairy. Terminal spur of anterior tibiæ ♂ ♀ trifid. Posterior tarsi slightly flattened, the first joint very little longer than the second, the fourth feebly emarginate. Elytra striate, feebly sinuate at tip, the intervals biseriately punctate, dorsal puncture not distinct.

Male. Anterior tarsi broadly dilated, the first four joints pubescent beneath, middle tarsi less dilated, pubescent or not.

Female. Anterior and middle tarsi slightly broader than the posterior, not pubescent beneath.

In consequence of the hairy head, it is difficult to determine the number of clypeal setigerous punctures. The first two species below have two certainly, and *piceus* but one.

The species of this group are as follows :

Thorax very distinctly narrowed behind, the sides arcuate.
  Hind angles of thorax obtuse. Intervals of elytra very irregularly biseriately punctulate. Middle tarsi ♂ not pubescent beneath.
    Posterior and middle tibiæ ♂ coarsely tuberculate externally. Sides of thorax beneath impunctate................1. **strenuus** Horn.
    Tibiæ spinulose externally. Thorax beneath punctate..2. **dilatatus** Dej.
  Hind angles of thorax distinct. Intervals of elytra very regularly and closely biseriately punctulate. Middle tarsi ♂ with joints 2—4 pubescent beneath.
    Spurs of hind tibiæ slender and acute.
      Hairs of surface short and erect. Thorax beneath with few obsolete coarse punctures..........................3. **obtusus** Lec.
      Hairs of surface long and scarcely erect. Thorax beneath with numerous coarse and deep punctures..............4. **pilosus**, n. sp.
    Spurs of hind tibiæ short, broad and dilated at tip, 5. **immanis**, n. sp.
  Hind angles of thorax sharply rectangular...........6. **brunneus** Dej.
Thorax scarcely narrower at base, sides feebly arcuate, hind angles obtuse. Clypeus with one setigerous puncture on each side. Middle tarsi ♂ pubescent beneath. Feebly pubescent.......7. **piceus** Ménét.

1. **A. strenuus** Horn. Our largest species, easily known in the group by its more robust and convex form and by the under side of the thorax being opaque and impunctured. The middle and posterior tibiæ in the male are roughly tuberculate on the outer margin. I have not seen the female. Length .60 inch ; 15 mm.

Two specimens ; Fort Tejon, California,

2. **A. dilatatus** Dej. With this species I unite *hirsutus*. It is much more depressed than the preceding species and the elytral intervals feebly convex. The middle and posterior tibiæ are simply spinulose externally, and the under side of the thorax sparsely obsoletely punctate. The punctures of the elytral intervals are coarse and very irregularly disposed. Length .32—.44 inch ; 8—11 mm.

Occurs nearly everywhere in California.

3. **A. obtusus** Lec. Similar in form to *dilatatus*, but smaller and with the hind angles of the thorax quite distinct but not prominent, and the disc more densely punctured. The underside of thorax has but few coarse punctures and these not deep. The hairs of the surface are short and erect, those of the elytra arising from the interstitial punctures which are very regularly and densely placed. The middle tarsi of the male have the three intermediate joints pubescent beneath. Length .30 inch ; 7.5 mm.

Occurs at San Jose, California.

4. **A. pilosus**, n. sp. Form rather narrow, elongate, piceous, feebly shining, pubescent, legs rufous. Head very coarsely and deeply punctured and with long hairs, clypeus with two larger setigerous punctures on each side. Thorax a little wider than long, narrowed behind, sides arcuate anteriorly, oblique posteriorly, hind angles distinct but not prominent, base slightly arcuate on each side, disc moderately convex, coarsely and deeply punctured, the punctures regularly placed, surface with moderately long hairs. Elytra a little wider than the thorax, oblong, sides very slightly arcuate, surface finely striate, intervals flat and regularly biseriately closely punctate, each puncture with a rather long semi-erect hair. Thorax beneath very coarsely and deeply punctate, metasternum at sides coarsely punctate, abdomen at sides more sparsely punctulate. Length .28 inch ; 7 mm.

This species is much more slender in form than *obtusus*, and differs also in the longer hairs of the surface and the sculpture of the thorax beneath. Sexual characters as in *obtusus*.

Occurs in the San Joaquin Valley, California. (Blüthner.)

5. **A. immanis**, n. sp. Oblong, depressed, piceous, feebly shining, pubescent, legs rufous. Head coarsely but not deeply punctate, with short erect hairs, clypeus with one setigerous puncture on each side. Thorax broader than long, narrowed posteriorly, sides in front arcuate, posteriorly oblique, hind angles distinct but not prominent, base on each side slightly arcuate, disc feebly convex, coarsely but not deeply punctate, surface with very short erect hairs. Elytra wider than the thorax, oblong oval, sides slightly arcuate, surface finely striate, intervals flat and rather finely and closely biseriately punctulate, with very short erect hairs. Thorax beneath with a few coarse punctures in front. Metasternum at sides and abdomen sparsely punctulate. Hind tibiæ with short, broad, spathuliform terminal spurs. Length .34 inch ; 8.5 mm.

I have seen but two females of this species, which bears considerable resemblance to *obtusus*, differing in the structure of the posterior tibial spurs. This character is so remarkable and unexpected in this genus that I would have passed the specimens as probable monstrosities, but the structure precisely agrees in the hind tibiæ of both specimens.

Two specimens ; San Joaquin Valley, California (Blüthner).

6. **A. brunneus** Dej. Resembles *piceus* in form but smaller, with the hind angles of the thorax rectangular and slightly prominent. I have never seen any specimen which agrees with the description excepting the type of Dejean in Chaudoir's collection. I have, however, in my cabinet an immature specimen which agrees with my recollection of that type, but which proves to be a Harpalus by the biseriately papillose tarsi. As the Dejean type is a female, a renewed examination is necessary to prove its generic position.

7. **A. piceus** Menét. In this species the thorax is very little narrowed behind, the posterior angles obtuse. The clypeus has but one setigerous

puncture on each side. The punctures of the elytral intervals are rather irregularly placed and are usually closer on the inner side of the interval than the outer. Length .36 inch ; 9 mm.

This is the most common species of the Pacific coast, occurring from Alaska to the Peninsula of California and the islands adjacent, it extends inland to Idaho and Utah.

A—b, *rusticus* Group.

Species oblong or somewhat oval, glabrous, surface usually opaque, rarely shining (*dulcicollis*) or metallic (*harpaloides*). Terminal spur of anterior tibiæ ♂ ♀ trifid. Posterior tarsi slender, as long as the tibiæ, the first joint as long as the next two, the fourth joint emarginate. Elytra striate, intervals impunctate, a distinct dorsal puncture, tip distinctly sinuate.

Male. Anterior tarsi broadly dilated, the first four joints densely pubescent beneath, middle tarsi dilated joints 2—3—4 densely pubescent, the first with a small pubescent space at tip (except in *harpaloides* where there is no pubescense).

Female. Anterior and middle tarsi not dilated (except in ***harpaloides*** and *opaculus* where the first joint is broader and stouter).

The clypeus on each side has but one setigerous puncture, except in *carbonarius* where there are two.

The dilatation of the first joint of the anterior tarsus of the female is not a character of great value. It is well marked in the two above mentioned, but less in the second than in the first. In *dulcicollis* also a slight thickening may be observed.

The species of this group are distinguished in the following manner :

Clypeus with one setigerous puncture on each side, prosternum at middle smooth, not pubescent.
  Surface shining.
    Surface with metallic lustre, aeneous, legs and antennæ pale. 8. **harpaloides** Ferté.
    Surface black, shining, legs black................9. **dulcicollis** Ferté.
  Surface opaque, very distinctly alutaceous.
    Form elongate parallel, thorax not narrowed in front, widest near the middle..10. **opaculus** Lec.
    Form more or less oval, thorax narrowed from base to apex, widest at base..11. **rusticus** Say.
Clypeus with two setigerous punctures on each side, prosternum at middle punctured and pubescent.
  Surface opaque, form elongate, thorax nearly as wide at apex as at base......................................12. **carbonarius** Say.

8. **A. harpaloides** Ferté. An oblong species, shining, with greenish or bluish metallic surface lustre. The clypeus has but one setigerous puncture on each side. Thorax as wide at base as apex, the sides feebly

arcuate. Elytra oblong, parallel or with the sides feebly arcuate, surface striate, intervals smooth and flat, a dorsal puncture in the usual position. The body beneath is smooth. Legs and antennæ rufous. Length .36—.40 inch ; 9—10 mm.

The *male* has the anterior tarsi dilated, the first joint much less so than the others and without pubescence beneath, the three following joints are normally pubescent; middle tarsi less dilated, first joint glabrous, next three pubescent. In the *female* the first joint of the anterior tarsus is rather broadly dilated and thickened, slightly prolonged under the second joint, not pubescent beneath, joints 2—5 slender ; middle tarsi slender.

The resemblance of this species to *Harpalus amputatus* is worthy of mention, they are almost undistinguishable by superficial comparison. It is remarkable also that the first joint of the anterior tarsus of the male should be so feebly dilated and that of the female so much so.

Occurs in the Gulf States.

9. **A. dulcicollis** Ferté. Form somewhat oval, black, shining, legs piceous. Thorax broader at base than apex and as wide as the elytra, sides moderately arcuate, hind angles obtuse, basal impressions moderate and with very few punctures. Elytra oval, sides moderately arcuate, surface striate, intervals smooth, slightly convex, dorsal puncture distinct. Body beneath smooth, shining. Length .44 inch ; 11 mm.

The anterior tarsus of the *male* is normally dilated, the first joint pubescent beneath, the middle tarsi nearly as broadly dilated, the first joint pubescent at tip.

In the female the tarsi are slender, the first joint of the anterior is however somewhat stouter than in *rusticus*. The elytra are less shining than in the male.

Occurs in the Gulf States and Missouri.

10. **A. opaculus** Lec. Elongate oval, subparallel, black, opaque. Thorax not wider at base than apex, sides feebly arcuate, hind angles obtuse, basal impressions feeble, surface impunctate. Elytra oblong, sides feebly arcuate, surface finely striate, intervals flat, at apex 3—5—7 with a few feebly impressed punctures, dorsal punctures normal. Body beneath smooth, shining, legs piceous. Length .44 inch ; 11 mm.

The *male* sexual characters are as in *dulcicollis*. The characters of the female are also similar but the first joint of the anterior tarsus is a little stouter but much less so than in *harpaloides*.

Having seen a typical specimen of *elongatus* Chaud., I have no hesitation in placing it with the present species, the differences given by that author are certainly more of an individual character than of a specific nature.

Occurs in Texas.

11. **A. rusticus** Say. With this species I unite not only those already suppressed by Dr. LeConte (List p. 12) but also *merula* Germ. and *haplomus* Chaud. The accumulation of large numbers of specimens shows

them to be inseparable. Chaudoir proposes to separate these forms by their dentate or simple humeri, *merula* and *pinguis* with dentate humeri, and *rusticus* and *haplomus* with simple humeri. These characters are not by any means as constant as could be desired. It is true that forms can be selected typifying about four species, but the vast mass of the specimens would occupy the intermediate ground. Locality also has but little to do with the variation except that the form usually called *merula* appears to be peculiar to the Southeastern States. Length very variable .36—.56 inch; 9—14 mm.

The *male* has the first four joints of the anterior tarsi dilated and pubescent beneath, the middle tarsi are nearly as widely dilated, the first joint very feebly pubescent at tip only. In the *female* the anterior tarsi are slightly broader than the middle, the first joint not stouter.

Occurs everywhere in the Atlantic region east of the Rocky Mountains.

12. **A. carbonarius** Say. Form oblong, black, feebly shining ♂ or opaque ♀. Clypeus with two setigerous punctures on each side. Thorax broader at base than apex, sides feebly arcuate, hind angles obtuse, base truncate, side margin depressed, broadly near the base, base externally and side margin punctulate, distinctly ♂, obsoletely ♀. Elytra oblong, sides nearly parallel ♂, or slightly arcuate ♀, surface finely striate, intervals slightly convex ♂ or flat ♀. Body beneath smooth, shining. Prosternum punctured and with erect hairs, intercoxal process coarsely punctate. Length .52 inch; 13 mm.

In the *male* the anterior and middle tarsi are dilated and pubescent beneath, the first joint of the middle pubescent over half its surface. In the *female* the characters are as in *rusticus*.

Occurs from the Middle States to Colorado.

B—a, *nigrita* Group.

Species oblong, surface either shining or opaque, glabrous. Terminal spur of anterior tibiæ ♂ ♀ dilated at middle. Posterior tarsi slender, nearly as long as the tibiæ, the first joint nearly as long as the next two together, the fourth joint feebly emarginate. Elytra striate, often very finely, intervals rarely punctulate, tip distinctly sinuate, second stria with a distinct dorsal puncture.

Male. Anterior tarsi broadly dilated, the first four joints densely pubescent beneath, middle tarsus nearly as widely dilated, the first joint pubescent at tip only, the next three densely pubescent over their entire surface.

Female. Anterior and middle tarsi slender or very feebly broader, not pubescent beneath.

The clypeus may have one or two setigerous punctures on each side, the number of species in the first series being greater than the second. Those with one puncture follow naturally after the *rusticus* group.

The species are as follows:

Clypeus on each side with one setigerous puncture.

Surface opaque, elytra feebly striate, especially at tip.

Hind angles of thorax obtuse, sides regularly arcuate, base as wide as the elytra....................................13. **furvus** Lec.

Hind angles of thorax sharply rectangular, sides of thorax slightly arcuate posteriorly, base narrower than the elytra (Pacific coast species).

Intercoxal process and middle of second abdominal segment punctured, punctures with short setæ. Metasternum in front and behind punctured.

Thorax feebly narrowed posteriorly, basal impressions very feeble, surface entirely punctured....14. **semipunctatus** Lec.

Intercoxal process and metasternum smooth.

Thorax with broad but very shallow basal impressions. Elytra broad, sides distinctly arcuate..........15. **consobrinus** Lec.

Thorax with rather deep linear impressions, Elytra nearly parallel..................................16. **californicus** Dej.

Surface shining in both sexes, elytra more deeply striate.

Elytral intervals feebly convex, quite distinctly but sparsely punctulate, elytra oblong, sides nearly parallel, surface feebly shining. 17. **interpunctatus** Kby.

Elytral intervals convex, smooth, elytra oval, sides arcuate, surface shining; form more robust....................18. **agricola** Say.

Clypeus on each side with two setigerous punctures.

Hind angles of thorax obtuse.

Side margin of thorax very distinctly depressed and with the base punctulate....................................19. **Harrisii** Lec.

Side margin of thorax scarcely depressed.........20. **nigerrimus** Dej.

Hind angles of thorax distinct, nearly rectangular.

Elytral intervals distinctly but sparsely punctulate, sides of elytra nearly straight, subparallel......................21. **nigrita** Dej.

Elytral intervals smooth, shining, sides of elytra distinctly arcuate, form more robust........................22. **melanopus** Hald.

To this group belongs *A. signatus* Illig., of Europe and Asia. It resembles *semipunctatus* Lec., and has but one setigerous puncture on each side of the clypeus. The intercoxal process is smooth. It differs from any of the species of the group by the first joint of the middle tarsus of the male having no pubescence beneath.

13. **A. furvus** Lec. Oblong oval, black, opaque. Clypeus with one setigerous puncture each side. Thorax very little wider at base than at apex, sides feebly arcuate, hind angles obtuse, side margin feebly depressed, surface smooth at middle, finely punctured at base and sides. Elytra finely striate, intervals flat, dorsal puncture normal, surface opaque, more so in ♀. Body beneath smooth, shining. Length .44—.50 inch; 11—12.5 mm.

In the *male* the anterior tarsi have the first four joints dilated and pubescent beneath, the middle nearly as wide, the first joint pubescent at tip only, the following three densely pubescent.

The *female* has the tarsi without pubescence, the anterior a little broader than the middle.

This species resembles some of the forms of *rusticus*, but the group characters readily distinguish it.

Occurs from Georgia to Louisiana.

14. **A. semipunctatus** Lec. Form oblong, moderately robust, black, subopaque. Clypeus with one setigerous puncture each side. Thorax broad, slightly narrowed behind, sides feebly arcuate, hind angles rectangular but not prominent, side margin narrowly depressed, surface punctulate, more densely at sides and base. Elytra a little wider than the thorax, finely striate, intervals flat and very obsoletely punctulate on the disc, distinctly punctate at tip, dorsal puncture normal. Metasternum at side obsoletely punctured, in front and behind also, the first ventral segment and prosternum with fine punctures bearing short setæ. Length .50 inch ; 12.5 mm.

The sexual characters are as in *furvus*.

A. similis Lec. and *puncticollis* Chaud. are the same. The first of these names is somewhat older than that which I adopt and has been rejected in favor of a more expressive name, no injustice being done to the original author.

15. **A. consobrinus** Lec. Similar to the preceding but with the thorax more narrowed behind and the hind angles sharply rectangular; the basal impressions are vague and very shallow. The elytra are similar, but without obsolete punctures on the intervals and the sides are more arcuate. The body beneath is smooth. Length .30 inch ; 12.5 mm.

The sexual characters as in *furvus*.

Occurs in California in the middle and southern portions.

16. **A. californicus** Dej. Resembles the preceding but the form is more slender and the thorax less broad with the hind angles less prominent ; the basal impressions are much deeper and more sharply defined and the surface much less densely punctulate. The body beneath is smooth. Length .50 inch ; 12.5 mm.

While in the two preceding species the sexes are nearly equally opaque, here the male is decidedly more shining.

Sexual characters as in *furvus*.

Occurs in Oregon, California and Nevada.

17. **A. interpunctatus** Kby. Oblong, black, shining (slightly opaque ♀). Head sparsely, finely punctulate, clypeus with one puncture on each side. Thorax much broader than long, base and apex equal, sides feebly arcuate, margin narrowly depressed, hind angles rectangular not prominent, basal impressions moderately deep, disc moderately convex, very sparsely punctulate at middle, more densely along the base and side. Ely-

tra oblong, sides nearly parallel, moderately deeply striate, intervals feebly convex and sparsely obsoletely punctulate. Body beneath smooth. Length .48—.50 inch; 12—12.5 mm.

Sexual characters as in *furvus*. The female is much less shining than the male and the fine punctuation of the intervals much less distinct.

This is the species which has heretofore borne the name *nigrita* and for which Chaudoir suggested the name *Lecontei*. The Kirbyan description will fit equally well either to the present species or the true *nigrita* and I prefer to adopt the above name rather than suggest a new one.

Occurs in Pennsylvania, Vancouver and Canada (Kirby).

18. **A. agricola** Say. Form oblong, moderately robust, black, shining. Thorax broad, base and apex equal, sides moderately arcuate, hind angles rectangular, not prominent, margin narrowly depressed, basal impressions well defined, linear, disc convex, surface smooth with few punctures along the base and margin. Elytra slightly oval, striæ deep, intervals moderately convex, smooth and impunctured. Body beneath smooth. Length .44—.56 inch; 11—14 mm.

Sexual characters as in *furvus*.

This is the most robust and convex species of the present group.

Occurs in Missouri, Kanas and Georgia.

19. **A. Harrisii** Lec. Oblong oval, black, shining. Clypeus with two setigerous punctures each side. Thorax moderately broad, sides regularly arcuate, widest at middle, hind angles very obtuse, side margin depressed more widely behind, disc moderately convex, median line distinct, basal impressions shallow, basal region and depressed margin punctulate. Elytra moderately deeply striate, intervals slightly convex, smooth. Body beneath smooth, a few punctures on the intercoxal process of the abdomen and on the front and posterior portions of the metasternum. Length .44—.48 inch; 11—12 mm.

Sexual characters as in *furvus*.

Occurs from Newfoundland to Pennsylvania.

20. **A. nigerrimus** Dej. Thorax moderately convex, side margin very slightly depressed at middle and not at all at the basal angles, the basal impressions are feeble, shallow and but little punctulate. The other characters are those of the preceding species. Length .44 inch; 11 mm.

Sexual characters as in *furvus*.

Occurs in the New England and Middle States.

21. **A. nigrita** Dej. The description already given of *interpunctatus* applies so exactly to this that I find no differences except, that in the present species there are two clypeal punctures on each side while in that there is but one. Length .50 inch; 12.5 mm.

Sexual characters as in *furvus*.

The determination of the present form as the true *nigrita* Dej. (*interpunctatus* ‡ Lec.) is made from a specimen compared by Chaudoir with Dejean's types.

Occurs in the New England and Middle States.

22. **A. melanopus** Hald. As the preceding species is parallel with *interpunctatus* so is the present with *agricola*. The differences, other than those drawn from the clypeus, are hardly of sufficient moment to be considered specific, and it is worthy of note that the present and preceding species differ from each other in the same manner as do 17 and 18. Length .52—.56 inch ; 13—14 mm.

Occurs in Pennsylvania and Illinois.

B—b, *discoideus* Group.

Species oblong, surface shining (at least in ♂), either glabrous or with very fine pubescence, variable in color and lustre. Terminal spur of anterior tibiæ dilated at middle. Posterior tarsi slightly flattened, shorter than the tibiæ, the first joint but little longer than the second, the fourth emarginate. Elytra striate, tip sinuate, intervals either smooth or punctulate alternately, dorsal puncture distinct.

Male. Anterior tarsi broadly dilated, the first four joints pubescent beneath. Middle tarsi feebly dilated, first joint glabrous, the next three feebly pubescent.

Female. Anterior and middle tarsi not dilated nor pubescent beneath. Surface usually less shining.

All the species of this group have two setigerous punctures on each side of the clypeus, except *nivalis*. In all, the basal impressions of the thorax are well marked.

The species are as follows :

Clypeus with one setigerous puncture on each side.
 Color variable, elytra ♀ subopaque and often ferruginous with discal piceous space. Intervals impunctate.......... .23. **nivalis**, n. sp.
Clypeus with two setigerous punctures on each side.
 Intervals of elytra impunctate, elytra in part at least and legs testaceous.
  Thorax piceous, testaceous at the sides...........24. **discoideus** Dej.
  Thorax entirely piceous......................25. **baltimorensis** Say.
 Intervals of elytra alternately punctulate.
  Punctulate near the apex only..................26. **pityohrous** Lec.
  Punctulate their entire length.................27. **porosus** Motsch.

23. **A. nivalis**, n. sp. Form oblong, moderately elongate, piceous, elytra variable, either piceous or brownish-testaceous, with a darker discal space, and subopaque ♀. Head nearly smooth, clypeus with one setigerous puncture each side. Thorax broader than long, narrowed behind, sides arcuate in front, sinuate posteriorly, hind angles obtusely rectangular, disc moderately convex, median line distinct, basal impressions short, deeply impressed and punctured. Elytra wider than the thorax, sides subparallel ♂ or slightly arcuate ♀, apex feebly sinuate, moderately deeply striate, intervals flat, surface shining ♂ or subopaque ♀, dorsal puncture normal. Body beneath smooth, first ventral segment punctured at middle. Legs piceous. Length .36—.44 inch ; 9—11 mm.

In the *male* the first four joints of the anterior tarsi are dilated (the first joint rather feebly) and pubescent beneath, middle tarsi less dilated, the first joint not pubescent, the next three pubescent. In the *female* the anterior and middle tarsi are slightly dilated but not pubescent beneath.

The males are usually entirely piceous in color, while in the females the elytra are brownish-testaceous with a large, darker discal space. There are however exceptions in both sexes. This species has heretofore been considered a variety of *pityochrous*, but beside the clypeal setæ, the present species differs in the absence of punctures on the alternate intervals near the tip, and the entire absence of any metallic surface lustre.

Occurs in Nevada, northern California, Oregon and Vancouver.

24. **A. discoideus** Dej. Form oblong, moderately elongate, piceous, sides of thorax and elytra and legs testaceous. Head piceous, clypeus with two setigerous punctures on each side. Thorax very little wider than long, narrowed at base, sides arcuate in front, sinuate posteriorly, hind angles sharply rectangular, side margin very narrowly depressed, disc moderately convex, smooth, punctured along the base, basal impressions short and deep. Elytra wider than the thorax, rather deeply striate, intervals slightly convex and smooth. Body beneath smooth, intercoxal process slightly punctulate. Length .44 inch; 11 mm.

The anterior tarsi of the *male* are not broadly dilated and the first joint has very little pubescence at tip, the middle tarsi are rather slender, the first joint glabrous, the next three feebly pubescent. In the *female* the anterior and middle tarsi are scarcely broader than the posterior.

Occurs from Pennsylvania to Missouri.

25. **A. baltimorensis** Say. Piceous, legs and elytra pale, the latter with darker discal cloud. Form and general characters of *discoideus* but more depressed and less shining. Length .36—.40 inch; 9—10 mm.

The anterior and middle tarsi of the *male* are more broadly dilated, otherwise the sexual characters are as in *discoideus*.

I adopt or rather retain Say's name for this species in preference to the older one of Fabricius. I can see no advantage in respecting priority in a case of this kind, as the older name carries with it an erroneous locality.

Occurs nearly everywhere in the Atlantic region.

26. **A. pityochrous** Lec. Form of the preceding, but a little more convex, with the surface varying from violaceous to greenish, the general color piceous. Thorax similar in form to *baltimorensis* but less broad, a little more convex and usually less punctured at base. Elytra also similar in form but more parallel, the striæ fine, the intervals flat and at apex 2—4 - 6 are distinctly punctured. Body beneath and legs piceous. Length .34—.38 inch; 8.5—9.5 mm.

Sexual characters as in *baltimorensis*.

Closely related to the next species, but differs in the punctuation of the elytral intervals and by the smooth head and absence of coarse punctures from the apex of the thorax.

Occurs from Colorado westward to California and Oregon.

27. **A. porosus** Motsch. Form of *baltimorensis*, piceous, surface with metallic lustre varying from violaceous to green. Head coarsely punctured above the eyes. Thorax usually coarsely punctured along the basal and apical margins, the hind angles rectangular, usually prominent. Elytra strongly sinuate at apex, the striæ fine, the alternate intervals usually more convex and impunctured, the flat intervals (2—4 —6) punctured from base to apex. Length .36—.42 inch; 9—10.5 mm.

Sexual characters as in *baltimorensis*.

It will be observed in this species, that those forms in which the elytral intervals are decidedly alternating in convexity are females. The punctuation of the flatter intervals varies from very fine to rather coarse, while there are specimens in which the convex intervals are punctulate, but less than the flat ones. By this explanation it will be easy to account for the numerous synonyms.

In recently collected specimens the fine punctures of the flat intervals bear short hairs.

I have placed *Harpalus alternans* Motsch. as a probable synonym, and I would have adopted this name for the species had I been absolutely certain of the correctness of this course.

Occurs from New Mexico to Oregon, following the distribution already noticed in many other species.

C—a. *amaroides* Group.

Species slightly oval, *Amara*-like, surface glabrous and variously colored, usually with slight metallic lustre. Terminal spur of anterior tibiæ slender. Posterior tarsi variable. Elytra sinuate at tip, striate, dorsal puncture distinct.

Male. Anterior tarsi rather broadly dilated, the first four joints densely pubescent beneath. Middle tarsi less dilated, the first joint entirely glabrous in *cœnus* or with slight pubescence at tip in the other two species, the next three joints pubescent beneath.

Female. Tarsi slender not pubescent beneath. Elytra less shining than the male.

There is but one setigerous puncture on each side of the clypeus in this group.

The species are as follows:

Posterior tarsi slender, the first joint fully equal to the next two. Metasternum at sides and intercoxal process smooth.

Thorax scarcely wider at base than apex. First joint of middle tarsus ♂ glabrous beneath. Species oblong..............28. **laetus** Dej.

Thorax broader at base, as wide as the elytra. First joint of middle tarsus ♂ pubescent at tip. Species oval..... .....29. **coenus** Say.

Posterior tarsi distinctly flattened, the first joint shorter than the next two. Metasternum at sides and intercoxal process punctate.

Sides of thorax behind nearly parallel, hind angles rectangular. Middle tarsus of male with first joint very slightly pubescent at tip,

30. **amaroides** Lec.

28. **A. laetus** Dej. Oblong, moderately elongate, parallel, piceous with aeneous metallic surface lustre, narrow margin of thorax and elytra and legs testaceous. Head smooth, clypeus with one setigerous puncture on each side. Thorax broader than long, sides regularly arcuate, hind angles distinct, base a little wider than apex, margin narrowly depressed and pale, disc slightly convex with few punctures near the base, basal impressions distinct but feeble. Elytra rather broadly striate, intervals flat, smooth, more shining in the male, apex feebly sinuate, side margin narrowly and epipleuræ pale. Body beneath smooth, shining, piceous, abdomen somewhat paler. Length .32—.34 inch ; 8—8.5 mm.

The *male* has the anterior tarsi rather broadly dilated, the first four joints pubescent beneath, the first at tip only, middle tarsi feebly dilated, the first joint with a small pubescent space at tip, the next three fully pubescent. In the *female* the tarsi are all slender.

Occurs in southern New Jersey, Georgia and Texas.

29. **A. coenus** Say. Oval, form of *rusticus*, piceous, moderately shining, surface with feeble metallic lustre. Head smooth. Thorax broad, narrowed in front, sides moderately arcuate, hind angles rectangular, side margin very narrowly depressed in front, more widely posteriorly, disc moderately convex, basal impressions broad and shallow and sparsely punctulate. Elytra striate, intervals flat, smooth, more shining in the male, apex feebly sinuate, epipleuræ usually paler. Body beneath smooth, piceous. Femora piceous, tibiæ and tarsi paler. Length .32 inch ; 8 mm.

Sexual characters as in *laetus*, except that the first joint of middle tarsi of male is entirely glabrous beneath.

Occurs in the Middle States region.

30. **A. amaroides** Lec. Oblong oval, piceous, moderately shining, surface with feeble metallic lustre, violaceous to greenish. Head smooth. Thorax broader than long, narrower at apex, sides in front moderately arcuate, posteriorly straight, parallel, hind angles sharply rectangular, margin narrowly depressed, more widely posteriorly, disc moderately coarsely sparsely punctulate in front, more densely at base, basal impressions moderately deep. Elytra striate, intervals flat, smooth, more shining in the male, apex distinctly sinuate. Body beneath piceous. Intercoxal process and sides of metasternum punctate. Legs piceous. Length .36—.46 inch ; 9—11.5 mm.

The sexual characters are as in *laetus*, the first joint of middle tarsi ♂ having a very small trace of pubescence at tip.

Occurs in California in the central valley.

C—b, *sericeus* Group.

Species oblong, black, opaque, densely punctulate, finely pubescent. Terminal spur of anterior tibiæ slender. Posterior tarsi slender, nearly as long as the tibiæ, the first joint as long as the next two. Elytra sinuate at tip, striate but without distinct dorsal puncture.

Male. Anterior tarsi dilated, the first four joints densely pubescent beneath. Middle tarsi dilated, the first joint pubescent over its entire surface, the next three densely pubescent.

Female. Tarsi slender, not pubescent beneath.

The clypeus has but one setigerous puncture on each side.

One species occurs in our fauna:

Thorax as wide at base as apex, hind angles rounded, intervals of elytra alternately with coarser punctures, irregularly placed. Femora black, tibiæ and tarsi pale..............................81. **sericeus** Harr.

81. **A. sericeus** Harris. Oblong, black, opaque. Head sparsely punctate. Antennæ rufous. Thorax broader than long, apex and base equal, sides regularly arcuate, hind angles rounded, disc feebly convex, surface sparsely punctate, more densely at base and near the sides. Elytra striate, intervals slightly convex, densely punctulate, each puncture with a short hair, apex sinuate, the alternate intervals with coarser obsolete punctures. Body beneath black, opaque. Femora piceous, tibiæ and tarsi pale. Length .40 inch; 10 mm.

The anterior and middle tarsi of the *male* are dilated, the first four joints pubescent, the first joint over nearly its entire surface. In the female these tarsi are slender.

Canada and Middle States to Nebraska.

In addition to the species described in the foregoing pages the following has been described:

Dichirus pallidus Motsch. Elongatus, parallelus, pallidus; capite, thorace elytrorumque medio infuscatis; mandibulis robustis; thorace subquadrato, postice angustato, angulis posticis obtusis; elytris thorace duplo longioribus, striatis, interstitiis impunctatis; pedibus ciliatis. Long 2¼ lin. —lat. 1 lin.

In addition the following characters are given:

There is no punctuation nor pubescence on the upper side of the body. The thorax is square, narrowed behind, the surface transversely rugulose. On each side of the base is a rounded shallow impression.

These characters seem to indicate that the species is not a *Dichirus* (group A—a) but that it is probably more closely allied to and possibly merely an immature form of *A. pitychrous* Lec.

It occurs in California.

Synonymy and Bibliography.

A. strenuus Horn, *Trans. Am. Ent. Soc., 1868, p. 130.

A. dilatatus Dej., Species iv, p. 241.
hirsutus Men., Bull. Ac. Petrop., ii, 1844, p. 61.

A. obtusus Lec.,* Ann. Lyc., v, p. 185.

A. pilosus, n. sp.*

A. immanis, n. sp.*

A. brunneus Dej.,* Species iv, p. 239.

A. piceus* Men., Bull. Acad. Petrop., ii, 1844, p. 61.
brunneus ‡ Mann., Bull. Mosc., 1843, ii, p. 212.
villosus Mots., Bull. Mosc., 1845, iv, p. 344.
irregularis Mots., loc. cit., p. 345.
parallelus Lec.,* Ann. Lyc., v, p. 184.

A. harpaloides Ferté, Ann. Ent. Soc. Fr., 1841, p. 203.

A. dulcicollis Ferté,* Rev. Zool., 1841, p. 44.
ellipticus Lec.,* Ann. Lyc., iv, p. 284.

A. opaculus Lec.,* New Species, 1863, p. 16.
elongatus Chaud.,* Rev. Mag. Zool., 1868, p. 13.

A. rusticus Say, Trans. Am. Phil. Soc., ii, p. 32; Lec. Ann. Lyc. iv, p. 284.
tristis Dej., Species iv, p. 158.
merula Germ., Ins. spec. nov., p. 24 ; Dej. Species, iv, p. 155.
pinguis Lec.,* Ann. Lyc., iv, p. 282.
crassus Lec.,* loc. cit., p. 282.
gravidus Lec.,* loc. cit., p. 283.
haplomus Chaud.,* Rev. Mag. Zool., 1868, p. 13.

A. carbonarius Say, Trans. Am. Philos. Soc., ii, p. 32.
luctuosus Dej., Species iv, p. 151.
rufipennis Lec.,* Ann. Lyc., iv, p. 281.

A. furvus Lec.,* New Species, 1863, p. 14.

A. semipunctatus Lec.,* Proc. Acad., 1859, p. 83.
similis Lec.,* Ann. Lyc., v, p. 183.
puncticollis Chaud.,* Rev. Mag. Zool., 1868, p. 11.

A. consobrinus Lec.,* Ann. Lyc., v, p. 183.
brevicollis Lec.,* loc. cit.

A. californicus Dej.,* Species iv, p. 148.
confusus Lec.,* Ann. Lyc., v, p. 183.

A. interpunctatus Kby., Fauna. Bor. Am., iv, p. 42, pl. 7, fig 8.
nigrita ‡ Lec.,* Ann. Lyc., iv, p. 279 ; New Species, 1863, p. 15.
Lecontei ‖ Chaud., Rev. Mag. Zool., 1868, p. 11.

A. agricola Say., Trans. Am. Philos. Soc., ii, p. 33.
paradoxus Hald.,* Proc. Acad., i, p. 302.
striatus Lec.,* Ann. Lyc., iv, p. 280.

A. Harrisii Lec.,* New Species, 1863, p. 14.

A. nigerrimus Dej.,* Species v, p. 842.
laticollis Kby., Fauna Bor. Am., iv, p. 43.
punctulatus Lec.,* New Species, 1863, p. 14.

A. nigrita Dej.,* Species, iv, p. 149.
interpunctatus ‡ Lec.,* Ann. Lyc., iv, p. 279.

A. melanopus Hald.,* Proc. Acad., i, p. 302.
agricola ‡ Lec.,* Ann. Lyc., iv, p. 279.

A. nivalis, n. sp.*

A. discoideus Dej.,* Species v, p. 831.

A. baltimorensis Say, Trans. Am. Philos. Soc., ii, p. 33; Dej. Sp. iv, p. 152.
Sanctæ-Crucis Fab., Ent. Syst. Suppl., p. 58; Schaum. Stett. Zeits., 1847, p. 47.

A. pitychrous Lec.,* Proc. Acad., 1861, p. 339.

A. porosus Motsch., Bull. Mosc., 1845, iv, p. 344.
sublævis Motsch.,* Bull. Mosc., 1859, iii, p. 138.
chalceus Lec.,* Col., Kansas, 1859, p. 2.
alternans Lec.,* Ann. Lyc., v, p. 184.
virulescens Lec.,* Proc. Acad., 1861, p. 339.
rudis Lec.,* New Species, 1863, p. 15.
Lecontei Harold, Catalogus, p. 256.
? alternans Mots. (*Harpalus*), Bull. Mosc., 1845, iv, p. 343.

A. laetus Dej.,* Species, iv, p. 154.

A. coenus Say, Trans. Am. Philos. Soc., ii, p. 34; Dej. Species, iv, p. 158.
subæneus Lec.,* Ann. Lyc., iv, p. 285.
obscurus Lec.,* loc. cit., p. 286.

A. amaroides Lec.,* Ann. Lyc., v, p. 184.

A. sericeus Harr.,* N. E. Farmer, 1828, p. 177.
femoratus Dej., Species, iv, p. 224.

A. (*Dichirus*) **pallidus** Mots., Bull. Mosc., 1859, iii, p. 187. Unknown to me.

Species marked * are those of which I have studied the type or a specimen carefully compared therewith.

Critical notes on the Species of SELENOPHORUS *of the United States. By George H. Horn, M. D.*

(*Read before the American Philosophical Society, Nov. 5th,* 1880.)

Without wishing at the present time to discuss the question of the validity of Selenophorus as a genus distinct from Harpalus, I will only state that no characters have yet been given which are permanent in all the species. Nevertheless it seems to be at least a well defined group in which there are three series of punctures or foveolæ situated on the second, fifth and seventh elytral striæ, a character which suggests a similar division of species in Pterostichus.

The only work in which the species of this genus has been treated as a whole is by M. Putzeys (Stettin Zeitschrift, 1878, pp. 1—73), whose arrangement, even with our small number of species, I have been unable to follow, the primary division being rather inexact and the secondary characters not easy to be perceived. There seems also to have been a tendency to exaggerate the importance of differences which are either individual or local and the number of species unnecessarily increased.

Since the reception of the above mentioned paper, material has gradually been accumulated in our cabinets from all parts of the country, which shows clearly that the species have a very wide range of distribution, and the variations between widely separated localities are well marked, while the differences become evanescent in intermediate localities.

All the species belong to the Atlantic fauna, several however extend through Arizona to the Peninsula of California, but none occur in the true Pacific fauna, that is from San Diego northward.

The following table gives in brief the characters separating the species recognized in the subsequent pages :

Prosternum obtuse at tip, not margined.
  Species with bronzed surface lustre.
    Intervals of elytra smooth, not pubescent, eighth stria not distant from margin.
      Elytra at tip feebly sinuate, the outer interval punctulate.
        Elytral punctures large, almost foveolate.......... **palliatus** Fab.
        Elytral punctures very small.................. **pedicularius** Dej.
      Elytra at tip strongly sinuate, the outer angle subdentate.
        Outer interval not punctulate...................... **fatuus** Lec.
    Intervals punctulate and pubescent, eighth stria more distant from the margin than from the seventh.............. **breviusculus**, n. sp.
  Species black above, more or less iridescent.
    Thorax as wide or wider at base than apex.
      Outer interval punctulate......................... **opalinus** Lec.
      Outer interval not punctulate..................... **gagatinus** Dej.
    Thorax distinctly narrowed at base.
      Hind angles obtuse.
        Marginal interval punctulate...................... **iripennis** Say.
      Hind angles rectangular and prominent........... **subtinctus** Lec.
Prosternum horizontal, tip slightly prolonged and margined.
  Thorax not broader at base than apex.
    Form rather narrow, elytral punctures foveolate...... **fossulatus** Dej.
    Form broader, elytral punctures small.................. **ovalis** Dej.
  Thorax broader at base than apex, sides nearly regularly arcuate from base to apex.................................... **ellipticus** Dej.

The characters above given seem sufficiently plain to need no comment. There have been no differences observed in the clypeal setigerous punctures, all the species having but one puncture on each side. The males have the anterior and middle tarsi moderately dilated, with two series of squamiform papillæ on the first four joints.

S. palliatus Fabr. Piceous, legs pale, upper surface shining, bronzed. Thorax equally wide at base and apex, sides feebly arcuate in front, hind angles distinct, nearly rectangular but not prominent, basal impressions moderate and with very few punctures. Elytra a little wider than the thorax, oblong oval, very feebly sinuate at tip, finely striate, striæ 2—5—7 each, with rather large punctures, the marginal interval finely punctulate and pubescent. Length .28—.32 inch; 7—8 mm.

With this species I unite *laesus* Lec., which differs only in having the dorsal punctures a little smaller. It is the largest species of the bronzed series in our fauna.

Occurs from Florida to the Peninsula of California.

S. pedicularius Dej. Oblong oval, piceous, shining, surface bronzed, legs pale. Thorax a little broader at base than apex, sides arcuate, hind angles obtuse, disc moderately convex, basal impressions almost entirely obliterated. Elytra scarcely wider than the thorax, finely striate, intervals flat, smooth, the marginal finely punctulate, striæ 2—5—7 with fine punctures, apex feebly sinuate. Length .20—.26 inch; 5—6.5 mm.

With this species I unite *troglodytes*, *aereus* and *puellus*. It is possible in a large series, such as I have now before me, to select forms which will agree in every particular with the descriptions of Dejean and Putzeys, but they are not species and do not deserve the name of varieties. *S. troglodytes* is more convex and the sides of the thorax a little more arcuate, the vast majority of these are females. The marginal punctation is said by Putzeys to be without pubescence; this is not true in any well preserved specimen. The description of *puellus* shows no character whatever of a specific nature. The *aereus* Lec. is placed by Putzeys in another series in which the tarsi are said to be long, but after a careful study of this character, I find it entirely deceptive and not of the value already observed in Anisodactylus. The posterior tarsi in all the bronzed species are somewhat broader than in the iridescent species, but their length as compared with the tibiæ is the same.

I cannot understand why Putzeys, after placing *puellus* next after *pedicularius* (12) and *troglodytes* (13) in the table, should place it as 55 near *aereus* (56) in the text.

Occurs from the Middle States to Kansas, Florida and Arizona.

S. fatuus Lec. Closely resembles the preceding but more slender in form. The thorax is less transverse, somewhat narrowed behind, the hind angles distinct. The elytra are similarly sculptured but the marginal interval is entirely impunctulate and consequently not pubescent, the apex is strongly sinuate, the outer angle of the sinuation quite prominent. Length .20—.24 inch; 5—6 mm.

This species is usually darker in color than *pedicularius* and more shining.

In this species Zimmerman (Trans. Am. Ent. Soc., 1869, p, 247,) recognized *parumpunctatus* Dej., and from the comparisons made by Putzeys, I am inclined to think that view correct, but not having types of Dejean's species, cannot say so definitely.

Occurs in the Gulf States.

S. breviusculus, n. sp. Oval, slightly oblong, facies robust, piceous, legs pale, surface feebly shining with distinct bronze lustre. Head punctulate, rugulose at the sides above the eyes. Thorax broad, apex and base equal, sides rather strongly arcuate, basal angles broadly rounded, base feebly emarginate at middle, disc convex, sides slightly depressed posteriorly, at middle more shining, finely transversely wrinkled, in front finely punctulate, at base and sides densely punctate and opaque. Elytra not wider than the thorax, scarcely one-third longer than wide, sides moderately arcuate, apex scarcely at all sinuate, moderately deeply but finely striate, intervals flat and irregularly but finely biseriately punctulate and pubescent, serial punctures very fine and indistinct, eighth stria distant from the margin. Body beneath feebly shining, abdomen sparsely punctate and with short pubescence. Legs testaceous, middle and posterior tibiæ slightly arcuate. Length .26 inch ; 6.5 mm.

This species is evidently allied to *crassiusculus*, *curvipes* and *arcuatus*, which Putzeys unfortunately omits from his synoptic table. It is very distinct from any other in our fauna in its general aspect as well as by the characters above given.

One specimen in my cabinet from Fort Cobb, Indian Territory, collected by Dr. Edw. Palmer, another in Mr. Ulke's cabinet.

S. opalinus Lec. Oblong, black, surface rather brilliantly iridescent. Head smooth, a foveate puncture more or less distinct on each side of the vertex. Thorax broader than long, base as wide as apex or a little wider, sides feebly arcuate, margin narrowly depressed and translucent, disc feebly convex, surface sparsely indistinctly punctulate along the base, hind angles distinct but obtuse. Elytra a little wider than the thorax, sides parallel ♂ or slightly arcuate ♀, apex feebly sinuate, surface rather deeply striate, intervals slightly convex, more so at apex and sparsely indistinctly punctulate, serial punctures distinct but not large, outer interval very distinctly punctate but not pubescent. Body beneath shining, abdomen sparsely indistinctly punctulate. Legs rufo-testaceous. Length .36—.40 inch ; 9—10 mm.

This is our largest species of the iridescent series.

Occurs from Wisconsin and Michigan to Florida and thence westward to the Peninsula of California.

S. gagatinus Dej. More slender and parallel than *opalinus* as well as more convex. The surface is also less iridescent, the thoracic margin extremely narrow and not translucent. The punctures of the elytral intervals are scarcely visible, while the marginal interval is absolutely smooth. Femora piceous, tibiæ and tarsi paler. Length .30 inch ; 7.5 mm.

To this species I refer some specimens collected by me in early Spring in Arizona which are probably immature. The head and thorax are rufo-piceous and the elytra more finely striate than in the normal form. I am unwilling to separate them until more mature specimens are seen.

Putzeys states in error that the prosternum is margined in this species.

Occurs from Massachusetts to Texas.

S. iripennis Say. Thorax broader than long, very distinctly narrowed posteriorly, hind angles distinct but obtuse, margin narrow and slightly translucent, disc smooth with few fine punctures in the vague basal impressions. Elytra broader than the thorax, sides feebly arcuate, apex scarcely sinuate, surface striate, striæ obsoletely finely punctulate, intervals flat, very obsoletely finely punctulate, the marginal usually distinctly punctulate. Legs testaceous. Length .26 inch ; 6.5 mm.

The narrowing of the thorax behind in this species is quite well marked, so that it resembles in form certain Bradycellus.

Occurs from Illinois to Georgia and Texas.

In the synoptic table given by Putzeys, *opalinus* and *gagtinus* are placed in a series in which the thorax is said to be "narrowed behind without prominent angles," while in the description the former is said to have a square thorax equally narrowed at apex and base, while the latter is said to be narrowed in front. They are also widely separated in the body of his paper with thirty-one species between.

S. subtinctus Lec. Closely resembles *iripennis*, but the thorax is more narrowed posteriorly and the hind angles sharply rectangular and slightly prominent. The outer elytral interval is very narrow and smooth. Legs pale rufo-testaceous. Length .24 inch ; 6 mm.

One specimen ; Louisiana.

S. fossulatus Dej. Oblong, depressed, black, surface with silken lustre. Thorax broader than long, base and apex equal, or the former slightly narrower, sides regularly arcuate, hind angles rectangular, not prominent. Elytra very little wider than the thorax, sides feebly arcuate, striæ very fine, serial punctures large and foveolate, apex feebly sinuate. Body beneath and legs piceous, shining, tibiæ and tarsi usually paler. Length .24 inch ; 6 mm.

This species is the least oval of this group and is easily known by the thorax, elytral punctures and lustre.

Occurs in Georgia and Florida.

S. ovalis Dej. Oblong oval, depressed, black, subopaque. Thorax with the base and apex nearly equal or very little broader at base, sides regularly arcuate, hind angles rectangular, not prominent. Elytra a little broader at base than the base of the thorax, sides moderately arcuate, apex very feebly sinuate, surface finely striate, intervals flat, serial punctures moderate in size. Body beneath and legs piceous, surface slightly iridescent. Length .28 inch ; 7 mm.

Occurs in Georgia and Florida.

S. ellipticus Dej. Oblong oval or elliptical, black, subopaque. Thorax wider at base than apex, sides regularly arcuate, hind angles rectangular. Elytra not wider than base of thorax, the margins of each nearly continuous, surface finely striate, intervals flat or very slightly convex, serial punctures very small, apex scarcely at all sinuate. Body beneath black, shining. Legs rufo-testaceous. Length .20—.24 inch ; 5—6 mm.

The males are a little more shining than the females. With this species I unite *granarius* Dej. The larger number of the species have the thorax regularly narrowing from base to apex, some few however have the base a little narrower than the disc, a little in front of the base, but the transition from one form to the other is very gradual.

Occurs from the Middle States to Georgia and Texas.

The three preceding species have the prosternum horizontal at tip, slightly prolonged and distinctly margined at the sides and apex. They form a very natural group.

SYNONYMY AND BIBLIOGRAPHY.

S. palliatus Fab., Ent. Syst. Suppl., p. 58.
stigmosus Germ., Ins. Spec. nov., p. 25 ; Putz. Stett. Zeits., 1878, p. 12.
impressus Dej., Spec., iv, p. 83 ; Ic., pl. 175, fig. 5.
laesus Lec., Proc. Acad., 1858, p. 59.

S. pedicularius Dej., Spec., iv, p. 100 ; Putz., loc. cit., p. 18.
troglodytes Dej., ibid., p. 101 ; Putz., p. 18.
aereus Lec., Ann. Lyc., iv, p. 293.
planipennis Lec., ibid., p. 294.

S. fatuus Lec., New Species, 1863, p. 17.
excisus ‖ Lec., Proc. Am. Philos. Soc., 1878, p. 377.

S. breviusculus Horn, n. sp.

S. subtinctus Lec., Proc. Acad., 1866, p. 365.

S. iripennis Say, Trans. Am. Philos. Soc., ii, p. 30.
varicolor Lec., Ann. Lyc., iv, p. 292.

S. gagatinus Dej., Spec., iv, p. 112 ; Putz., loc. cit., p. 43.
maurus Hald., Proc. Acad., i, p. 306.
viridescens Lec., Ann. Lyc., iv, p. 292.

S. opalinus Lec., List. Col., N. A., p. 18 ; Putz., loc. cit., p. 52.
iripennis ‡ Lec., Ann. Lyc., iv, p. 289.

S. fossulatus Dej., ibid., p. 88 ; Putz., loc. cit., p. 15.

S. ovalis Dej., Spec., iv, p. 106 ; Putz., loc. cit., p. 20.

S. ellipticus Dej., ibid., p. 108 ; Putz., loc. cit., p. 20.
granarius Dej., ibid., p. 109 ; ibid., p. 21.
pulicarius Dej., ibid., p. 108.

List of Papers Communicated to the American Philosophical Society. By Pliny Earle Chase, LL.D.

(*Read before the American Philosophical Society, November* 5, 1880.)

1. Sanscrit and English Roots and Analogues. Sept. 17, 1858, *P.** vii, 177–91.
2. Chinese and Indo-European Roots and Analogues. Jan. 18, 1861, *P.* viii, 5–48.
3. Intellectual Symbolism. Oct. 3, 1862, *T.** xii, 463–594.
4. Chinese Seal Inscriptions. Feb. 6, 1863, *P.* ix, 139.
5. Chinese Analogues in other languages. Feb. 20 to May 15, 1863, *P.* ix, 145, 172, 231.
6. Catalogue of Trade Tokens circulating during the war of the Rebellion. Sept. 18, 1863, *P.* ix, 242–58.
7. Mathematical Probability of Accidental Linguistic Resemblances. Sept. 18, 1863, *T.* xiii, 25–33.
8. Comparative Etymology of the Yoruba Language. Sept. 18, 1863, *T.* xiii, 35–68.
9. Note on Possible Vowel Sounds not used in any Language. Oct. 2, 1863, *P.* ix, 271.
10. On the Diurnal Variations of the Barometer; elastic actions and reactions proportioned to mass; cyclical motions in a resisting medium, furnishing *harmonic indications of Sun's mass and distance;* anticipation of astronomical verifications or rectifications by means of varying pressures; *importance of the fundamental equations,* $v = \frac{gt}{2}$; $h = \frac{gt^2}{4}$; in which t represents the time of cosmical, molecular, or atomic rotation, and g represents the acceleration of a central force. Dec. 18, 1863, *P.* ix, 283–8 (Maxwell, Edlund, Crookes, Lockyer).†

The above was the first of a series of physical papers in confirmation of the following *General Postulate. All physical phenomena are due to an Omnipresent Power, acting in ways which may be represented by harmonic or cyclical undulations in an elastic medium.*

11. On the Height of the Tides; principles of (10) applied to the explanation of some tidal anomalies. Jan. 1, 1864, *P.* ix, 291–4.
12. Daily Distribution of Heat; coördinate thermodynamic influences of solar radiation, cyclical elasticity, and barometric pressure. March 4, 1864., *P.* ix, 345–9.
13. Mechanical modification of electric and other elastic currents; gravity, electricity and terrestrial magnetism regarded as "modes of motion" (Gray, Edison, Bell, Channing, Crookes); illustrations of the

* *P., Proceedings; T., Transactions.*

† The names in parentheses are those of subsequent investigators, whose researches have confirmed the conclusions of the papers.

hypothesis that electricity consists simply of ætherеal vibrations (Maxwell, Edlund). April 1, 1864, *P.* ix, 355–60.

14. Polarizing influences of thermal convection and radiation: correspondence between Challis's laws of molecular action and the laws of attraction and rotation (Baumhauer, Meyer, Mendelejeff, Zaengerle). April 15, 1864, *P.* ix, 367–71.

15. Lunar-monthly barometric variations: resemblances to daily barometric fluctuations. June 17, 1864, *P.* ix, 395–9. Also, Proc. Roy. Soc. June 16, 1864, xiii, 329–333.

16. Component elements of normal barometric tides; influence of oscillations moving with the velocity of light. July 15, 1864, *P.* ix, 405–11.

17. Comparative fitness of languages for musical expression. Sept. 16, 1864, *P.* ix, 419–20.

18. Primitive names of the Supreme Being. Sept. 16, 1864, *P.* ix 420–4.

19. Numerical Relations ot Gravity and Magnetism; Formulation of Hypothesis of Unity of Elastic Force; Kinetic Ratio of Sound Waves to Light Waves (Edlund, Mendelejeff, Crookes, Lockyer, Edison). Oct. 21, 1864, *P.* ix, 425–40; *T.* xiii, 117–36.

20. Comparison of Solar and Lunar Magnetic and Aerial Tides; Magellanic medal awarded Dec. 16, 1864 (Maxwell, 1873). *P.* ix, 487–95.

21. Radical Significance of Numerals. Feb. 17, 1865, *P.* x, 19–23.

22. Copto-Egyptian Vocabulary. April 7, 1865, *P.* x, 69–94.

23. Relations of Magnetic Declination to Gravity: Heat and Attraction; Different manifestations of the Force which controls Stellar-Systems as well as Molecular Motions. April 21, 1865, *P.* x, 97–104.

24. Relations of Magnetic Inclination to Gravity: Accomplishment of Faraday's Desideratum. May 19, 1865, *P.* x, 111–8.

25. Experiments in Mechanical Polarization of magnetic needles by vibrations resembling those of Terrestrial convection and atmospheric currents: mechanical polarization of Sky Light. Oct. 6, 1865, *P.* x, 151–66.

26. Observations on Skylight polarization at Philadelphia: Remarkable visibility of all the neutral Points. Jan. 5, 1866, *P.* x, 196–7.

27. Comparative visibility of Arago's, Babinet's, and Brewster's Neutral Points, in Philadelphia and its neighborhood. April 6, 1866, *P.* x, 223.

28. Relations of Temperature to Gravity and Density: General Equation of Oscillation and Parabolic motion; Thermodynamic *vis viva;* Comparative Energy of action and reaction at the source of Solar Radiation and at Earth's Orbit: simple harmonic relation between terrestrial gravity and the velocity of light. Sept. 21, 1866, *P.* x, 261–9.

29. Laws regulating the distribution and transmission of Solar heat. Feb. 1, 1867, *P.* x, 309–15.

30. Probabilities in etymology; a reply to criticism. Sept. 20, 1867, *P.* x, 345–9.

31. Meteor seen at Haverford College. Oct. 4, 1867, *P.* x, 353.
32. Meteors of Nov. 13, 14, 1867. Nov. 15, 1867, *P.* x, 357.
33. Specific Magnetism of iron; cosmical and molecular comparisons. Nov, 15, 1867, *P.* x, 358.
34. General connotations of magnetism; accordance between barometric and astronomical estimates of Sun's distance. Feb. 21, 1868, *P.* x, 368–79.
35. Evidences of Lunar influence on rainfall. June 19, 1868, *P.* x, 436–9.
36. Tidal Rainfall of Philadelphia; similarity of influence in different independent periods. Dec. 4, 1868, *P.* x, 523–37.
37. Meteors of Nov. 13, 14, 1868. Dec. 4, 1868, *P.* x, 539.
38. Philadelphia Life Tables. Feb. 5, 1869, *P.* xi, 17–22.
39. Cosmical relations of light to gravity; influence of the *modulus* of light, velocity, mass, distance, centres of gyration, orbital eccentricity, inertia, and ratio of circumference to diameter on cosmical and molecular phenomena (Alexander, 1877); solar centripetal reaction against the action of gravity towards the centre of the solar system gives *the velocity of light* in the fundamental equation $v = \frac{gt}{2}$. April 2, 1869, *P.* xi, 103–7.
40. Comparison of rainfall at Greenwich and Philadelphia; cosmical and local influences upon meteorology. May 7, 1869, *P.* xi, 113.
41. Tidal Rainfall; comparison of lunar influences at Providence, Chiswick and Toronto. Oct. 1, 1869, *P.* xi, 203.
42. Comparison of mechanical Equivalents. Jan. 7, 1870, *P.* xi, 313.
43. Monthly variations of rainfall at Philadelphia. Feb. 4, 1870, *P.* xi, 314–5.
44. European and American rainfall; comparison of quarterly rains at Philadelphia and Lisbon. March 3, 1871, *P.* xii, 38–9.
45. American Weather Notes; local influences; importance of gradients; frequency of anticyclonic storms; local cyclones in general anticyclones (Signal Service). March 3, 1871, *P.* xii, 40.
46. Winds of the United States; General anticyclonism; storm centres at normal intersections of prevailing currents. March 17, 1871, *P.* xii, 65–7.
47. Resemblance of atmospheric, magnetic and oceanic currents; primary coördinate great circles; uniform evidences of gravitating influence. April 7, 1871, *P.* xii, 68–70.
48. Relation of Auroras to gravitating currents. May 5, 1871, *P.* xii, 121–2.
49. Winds of Europe. June 16, 1871, *P.* xii, 123.
50. Normal position of the tidal ellipsoid. June 16, 1871, *P.* xii, 123–4.
51. Cyclical Rainfalls at Lisbon; solar and lunar influences compared at different independent periods; blending tidal currents of different temperatures and different degrees of humidity. Aug. 18, 1871, *P.* xii, 178–90.
52. Correlations of cosmical and molecular force; harmonic estimates of solar mass and distance from the explosive energy of oxygen and hy-

drogen (Young); *vis viva* of wave propagation = $\frac{1}{3}$ of the *vis viva* of oscillating particles (Maxwell, 1877). Feb. 16, 1872, *P.* xii, 892–4.

53. The Herschel-Stephenson Postulate; conditions of stability in elastic atmospheres; influences of centres of oscillation on planetary masses, distances, and times of rotation. March 1, 1872, *P.* xii, 395–7.

54. Further approximations to sun's distance; accordant harmonies of terrestrial rotation, lunar distance, lunar revolution, explosive energy, and the velocity of light. April 5, 1872, *P.* xii, 398–400.

55. General relation of Auroras to Rainfall. April 5, 1872, *P.* xii, 400.

56. Influence of meteoric showers on Auroras. May 16, 1872, *P.* xii, 401–3.

57. Planetary Illustrations of Explosive Oscillation; apsidal and mean positions and eccentricities (Alexander, 1877). May 16, 1872, *P.* xii, 403–5.

58. Undulatory harmonies of solar and planetary rotation, revolution, mass, gravity, and light. May 16, 1872, *P.* xii, 406–7.

59. Aethereal density and polarity; influences on cosmical masses and relative positions. May 16, 1872, *P.* xii, 407–10.

60. The sun-spot cycle of 11.07 years; wave-cycle of Jupiter's projectile locus (mean perihelion distance). May 16, 1872, *P.* xii, 410–1.

61. Aethereal Oscillation, the primordial material Force; cardinal centres of wave influence; planetary illustrations. July 5, 1872, *P.* xii, 411–7.

62. Daily auroral and meteoric means. Sept. 20, 1872, *P.* xii, 516–8.

63. Stellar and Planetary Correlations; relations of distance to cardinal points of explosive oscillation; rupturing velocities acquired by nebular "subsidence" from nd to $\frac{nd}{n+1}$; evidences of parabolic projection between *a Centauri* and sun, *the locus of the paraboloid being determined by the solar modulus of light, sun's linear centre of oscillation, and sun's gravitating reaction against luminous undulation;* harmonic positions of loci of planetary rupturing velocities. *These are the only* POSITIVE *evidences yet discovered of gravitating influence between different stellar systems.* Sept. 20, 1872, *P.* xii, 518–22.

64. Cyclical rainfall at San Francisco; indications of planetary as well as lunar influence. July 19, 1872, *P.* xii, 523–42.

65. Recent monthly Rainfall in the United States; compiled from Signal Service reports; lunar influence less disguised than solar. Nov. 1, 1872, *P.* xii, 555–7.

66. Lunar-cyclical Rainfall in the northern Temperate Zone. Nov. 1, 1872, *P.* xii, 558–9.

67. Oscillatory Forces in the Solar system; harmonies of apsidal and mean planetary positions and moments of inertia; influence of the ratio of the circumference to the diameter of a circle (Forbes, 1880). Feb. 7, 1873, *P.* xiii, 140–1.

68. Estimate of solar mass and distance from the equilibrium of elastic and gravitating forces. Feb. 7, 1873, *P.* xiii, 142–3.

69. Note on Planeto-Taxis; reasons for limitations of "Bode's law." March 7, 1873, *P.* xiii, 143–4.
70. Rotation of the sun and the Intra asteroidal Planets. March 7, 1873, *P.* xiii, 145–7.
71. Planetary relations to the sun-spot period. March 7, 1873, *P.* xiii, 147–8.
72. Relative velocities of light and gravity. March 7, 1873, *P.* xiii, 148–9.
73. The gamuts of sound and light; correspondence of wave-length of the musical note, $C_{,,,}$ with that of the Fraunhofer C line; approximations in other wave-lengths of the two gamuts; comparative harmonic estimates of solar mass and distance; indications of a magnetic gamut, four octaves below that of light. March 21, 1873, *P.* xiii, 149–54.
74. The music of the spheres; apsidal and mean relations to musical intervals. April 4, 1873, *P.* xiii, 193–8.
75. Harmonic Indications of Intra-Mercurial planets; influence of Neptune, Jupiter and Sun in establishing harmonic nodes of planetary aggregation; *prediction of an "unknown planet or other seat of solar and planetary perturbation"* (De la Rue, Stewart and Loewy, Watson, Mouchez, Oppolzer, and others). May 2, 1873, *P.* xiii, 237–9.
76. Correlations of Planetary mass. May 16, 1873, *P.* xiii, 239–43.
77. Harmonies of Cosmical Rotation. May 16, 1873, *P.* xiii, 243–8.
78. Weather Study; confirmation of views (45, 46) by observations of signal service bureau. May 16, 1873, *P.* xiii, 248–52.
79. The Planetary node between Mercury and Vulcan. May 16, 1873, *P.* xiii, 252.
80. Recent Confirmation of an Astronomical Prediction. Oct. 3, 1873, *P.* xiii, 470.
81. Comparison of Planetary Series; harmonic series the closest of all. Oct. 3, 1873, *P.* xiii, 471–7.
82. Transcript of a curious MS. work in cypher, supposed to be astrological. Oct. 3. 1873, *P.* xiii, 477–82.
83. Origin of Attractive Force. Feb. 6, 1874, *P.* xiv, 111–4.
84. Saving Fund Life Insurance. April 3, 1874, *P.* xiv, 148–9.
85. Cosmical Thermodynamics; fifty postulates of unitary force, with references to illustrative papers. April 17, 1874, *P.* xiv, 141–7.
86. Cosmical evolution; relations of mean proportionality to time, mass, density, and the velocity of light. May 15, 1874, *P.* xiv, 159-61.
87. Jupiter-cyclical Rainfall. June 19, 1874, *P.* xiv, 193–5.
88. Cyclical rainfall at Barbados. June 19, 1874, *P.* xiv, 195–216.
89. Gravitating Waves; important nodal positions of Sun, Earth and Jupiter. Jan. 1, 1875, *P.* xiv, 344–6.
90. Lunar monthly Rainfall in the United States, from observations of the Signal Service Bureau. April 16, 1875, *P.* xiv, 416–8.
91 Further Relations of Magnetic, Gravitating and Luminous Force; analogous equations in general physics, electricity, chemistry, and

cosmogony; consequent estimate of Sun's mass, from Maxwell's magnetic data. June 18, 1875, *P.* xiv, 607–9.

92. Planetary Illustrations of the Creative Fiat. Aug. 20, 1875, *P.* xiv, 609–12.

93. Yearly rainfall in the United States, from observations of the Signal Service Bureau. Aug. 20, 1875, *P.* xiv, 613–4.

94. The Beginnings of Development; planetary linkages; *the velocity of light is the limit between the living forces of association and dissociation;* variety of rhythmical relations; successive steps of nebular condensation. Sept. 17, 1875, *P.* xiv, 622–31.

95. Further Dynamic Coördinations; *mathematical deduction of the ratio between the mean vis viva of gaseous volume (heat under constant volume) and the vis viva of uniform velocity (heat under constant pressure)*; harmonies of products and powers of mass and distance. Dec. 3, 1875, *P.* xiv, 651–8.

96. Nebular action in the solar system; confirmations of Herschel's theory of "subsidence;" electrical conductivity of selenium, illustrating the ratio of velocities between solar waves originating at Sun's surface and in Earth's orbit (Bell, Tainter). April 21, 1876, *P.* xvi, 184–92.

97. On some fundamental propositions of central force; nucleal radius varying as the $\frac{2}{3}$ power of the atmospheric radius; oscillatory formulas of cyclical motion; views of various investigators; universal correlations. July 21, 1876, *P.* xvi, 298–310.

98. Aethereal influences in the solar system; evidence of 58 accordances. Jan. 5, 1877, *P.* xvi, 496–505.

99. Chemical atoms, molecules and volumes; laws of Boyle, Charles, and Avogadro. Feb. 2, 1877, *P.* xvi, 505–8.

100. Further illustrations of central force; increase of velocity through "subsidence" should produce rupture in the periphery of a stationary nebula at $\frac{r}{n}$ when $n = 2 + (8 - 2\sqrt{2})$; this influence shown by various planetary belts and positions; "subsidence" tending to form confocal elliptic orbits, with major axes of $\frac{3r}{2}$ and minor axes $\sqrt{2}\, r$, and belts, on account of collision, at $\frac{2r}{3}$; influence of the modulus of light and various ratios in positing planetary belts. July 20, 1877, *P.* xvii, 98–100.

101. Harmonies of solar spectrum; identity of law in luminous and planetary nodes. August 24, 1877, *P.* xvii, 109–12.

102. Results of wave interference; symmetrical formula, introducing masses of Sun and Jupiter, Sun's equatorial radius, Jupiter's projectile radius, and the velocity of light; significance of Earth's position and density; cosmical and molecular wave lengths: confirmation of "subsidence" and of harmonic undulations, by the moons of Earth, Mars, Jupiter, Saturn, and Uranus; *Alexander's adoption and confir-*

mation of my harmonic predictions. Jan. 18, 1878, *P.* xvii, 294–307.

103. Criteria of the Nebular Hypothesis. March 1, 1878, *P.* xvii, 341–5.
104. Radiation and rotation; explanation of Kirkwood's analogy; belts of planetary pairs. June 21, 1878, *P.* xvii, 701–4.
105. Crucial Harmonies; nine confirmations of prediction. Oct. 4, 1878, *P.* xviii, 34–6.
106. The limiting constant of gravitation: new method of identifying the velocity of light with gravitating force. Oct. 18, 1878, *P.* xviii, 41–3.
107. The Philosophy of Christianity. Feb. 7, 1879, *P.* xviii, 129–53.
108. Further confirmations of prediction; two additional evidences of harmonic solar disturbance. Feb. 21, 1879, *P.* xviii, 209.
109. Harmonies of Lockyer's "Basic Lines;" the fundamental wave-length representing a centre of spherical gyration, in Earth's reaction against solar action; the other lines all harmonic. April 4, 1879, *P.* xviii, 224–6.
110. Spectral estimates of Sun's distance. April 4, 1879. *P.* xviii, 227–9.
111. Correlations of mass: equations between masses of Sun and four outer planets; centres of various nebular influences. April 4, 1879, *P.* xviii, 229–32.
112. Approximate quadrature of the circle. June 20, 1879, *P.* xviii, 281.
113. Apparent semi-diameter of the Sun, and nebular origin of the terrestrial day. Dec. 19, 1879, *P.* xviii, 380–1.
114. Velocity of light and Kirkwood's analogy; *five estimates of the velocity of light based on the Nebular Hypothesis.* Jan. 2, 1880, *P.* xviii, 425–9.
115. Controlling centres; various estimates of mass and distance according to the Nebular Hypothesis. Jan. 2, 1880, *P.* xviii, 429–34.
116. Nodal estimate of the velocity of light. March 19, 1880, *P.* xviii, 4–9.
117. Cometary Paraboloids; comparison of planetary positions as determined by inter-stellar action, with M. Gaussin's geometrical approximations; stellar approximations the closest. April 16, 1880, *P.* xviii, 18–20; also *Comptes Rendus,* 19 Avril and 3 Mai, 1880, *T.* xc. pp. 912,1061.
118. Cosmical determination of Joule's equivalent; correspondence of centrifugal "lift," indicated by the difference of polar and equatorial temperatures, with the centripetal fall which would give the equatorial velocity of rotation; confirmation of Clarke's discovery, that the molecular volume of chemically combined water is variable, while that of crystal water, or molecularly united water, is invariable. April 16, 1880, *P.* xviii, 20–1.
119. Relations of Chemical Affinity to Luminous and Cosmical Energies; simple ratio of mean molecular velocities in gases, to velocities of terrestrial rotation and revolution; harmonic wave-lengths in Vogel's hydrogen and Paalzow's oxygen-spectra. April 16, 1880, *P.* xviii, 21–5.

Stated Meeting, November 19, 1880.

Present, 16 members.

President, Mr. FRALEY, in the Chair.

A letter of acknowledgment was received from the New York Academy of Sciences, October 23 (68, 75, 76, 79, 80, 89, 97, 102, 104).

A letter of envoy was received from the Royal Dublin Society, dated September, 1880.

Donations for the Library were received from the Mining Department, Melbourne; Academies at St. Petersburg and Berlin; Batavian Society, Harlem; Geographical Society and Revue Politique, Paris; Revista Euscara, Pamplona; Nature, London; Essex Institute, Salem; Professors Brush and Dana, New Haven; Franklin Institute, Historical Society, American Numismatic and Antiquarian Society, Editor of the American, and Mr. Henry Phillips, Jr. Philadelphia; Revista Cientifica and Ministerio de Fomento, Mexico.

The death of Mr. Henry Wharton, November 11, at Philadelphia, aged 53, was announced by Mr. J. S. Price, and, on motion, Mr. Jos. B. Townsend was requested to prepare an obituary notice of the deceased.

The death of Dr. Alexander Wilcocks, November 10, at Philadelphia, aged 62, was announced by Mr. Price..

The death of Prof. John Rudolf von Wagner, at Würtzburg, October 4, aged 58 (born at Leipsig, February 13, 1822), was announced by the Secretary.

Mr. Dubois offered the following from his note-book, in the U. S. Mint:

"November 19, 1880. Professor Baird, of the Smithsonian Institution, brought an engraved disk for examination. It was found in Guatamala, and at first view it seems to be a coin. It is not that, however; the lines and figures being chased with a graving tool, quite too slow an operation for making currency.

"On one side is a wolf, among trees; and on the other a tapir, behind which stands a man. A hole, rudely punched, must have served for hang-

ing the piece around the neck, as an ornament or amulet. There is no attempt at lettering.

"The measures are: Diameter, 1.4 inch; thickness, 75 thous. of an inch; weight, 18¼ grammes; sp. gr. 8.80.

"This last, together with the color and the good preservation, indicate a mixture of copper and tin.

"It bears some testimony to the condition of the aboriginals, and in that view is interesting.

"Mr. Phillips expressed the opinion that the piece was not much more than a century old."

Mr. Lesley exhibited and described three models in plaster:

1. Of the Seven Mountains in Middle Pennsylvania, surveyed by Charles E. Billin.

2. Of the Stone Mountain Fault, by Mr. Charles E. Billin.

3. Of a part of the Middle Anthracite Coal Field, constructed from the first specimen sheet map of the Anthracite Survey, by Mr. Charles A. Ashburner.

The minutes of the last meeting of the Board of Officers and members in council were read, and the following resolutions were adopted:

1. *Resolved*, That the Society has no power to modify the regulations prescribed by the donor (Mr. Magellan) for the awarding of the Magellanic premium.

2. *Resolved*, That the third condition precludes the awarding said premium to any person who has already published his or her discovery in taking out a patent, and who is also rewarded therefor by the monopoly conferred by the letters patent.

3. *Resolved*, That Chapter XII of the By-Laws be printed on the fly-leaf of each number of the Proceedings until further orders.

Four other resolutions recommended for consideration were postponed for the present, one of them involving a change in the By-Laws, and requiring certain preliminary formalities. (See Minute Book.)

Pending nominations Nos. 909, 920, 921, 922, and new nominations Nos. 923, 924, 925, were read, and the meeting was adjourned.

Notes on the Models Exhibited at the Meeting November 19, 1880. By J. P. Lesley.

These models were made by and under the superintendence of Mr. Ed. B. Harden, Topographical Assistant of the Second Geological Survey of Pennsylvania, and form part of a collection of models in the Museum of the Survey, No. 907 Walnut street, Philadelphia.

Each is constructed on one and the same vertical and horizontal scale to avoid structural distortion; but the scale of the first is 1 mile: 1″; that of the second 1600′: 1″; and that of the third 800′ : 1″.

The model of the Seven Mountains represents a district of anticlinals and synclinals, forty miles long, extending along the north side of the Kishicoquillas valley in Centre and Union counties. Parallel anticlinal ranges of Medina and Oneida, dying down eastward into Union, and westward into Huntingdon counties, form a mountain belt between the Siluro-Cambrian lowlands of Kishicoquillas valley in Mifflin and Snyder counties in the south, and Pine Creek, Brush and Nittany valleys of Clinton and Centre counties on the north. The broad rounded spurs sinking with the axis of each anticlinal beneath the Clinton red shale and fossil iron ore beds, are finely shown. In the heart of the region the anticlinal mountains split open, and show long narrow deep vales of Hudson river slate, while the synclinals contain long narrow strips of Clinton red shale.

In two places occur diagonal upthrow faults on a large scale, one through the Stone Mountain at Greenwood furnace; the other (in a prolongation of the line of the first fault), some miles further to the north-east.

Both faults have the western portion thrown northward and backward towards the north-east, as in a diagonally splintered arm bone drawn together by the contraction of the muscles; and this structure is plainly exhibited by the termination against each side of each fault of the Medina mountain crest, and of the Oneida terrace which always accompanies it.

The model of the Stone Mountain fault shows the structure on a large scale, and especially the slight curves at the ends of the hypothetical straight line of the fault, as well as the crushed and packed-in condition of the red shales around the north-east end of the fault. In the case of the other fault, there is a much greater complication; for two cross faults, at the two ends of the main slide line, parallel to each other, must be imagined to satisfy all the surface conditions.

The model of the Mammoth bed floor in the Schuylkill county is the first of this kind constructed in the Anthracite region. There is a model of the same kind in the Museum of the Towne School of the University of Pennsylvania, showing the floor of the Pittsburgh coal bed in Somerset county, Pennsylvania, which I had made by my students from data obtained by a special survey ordered by the Board of Commissioners of the Geological Survey in 1875. But the Anthracite basins are deep, steep sided, and with their separating anticlinals sometimes overthrown towards the north and collapsed. These are the most striking features of this model.

It also exhibits for the first time another unexpected and very important

feature, viz: the kettle-shaped isolation of the subordinate synclinals, which ride upon the crests of anticlinals at their ends. In fact, the views which we have hitherto held of the general continuance and parallelism of the sub-basins receives here a rude shock. The greatest irregularity prevails in the arrangement of the mutually interlocking sub-anticlinals and sub-synclinals. At the same time it is most interesting and satisfactory to see that in this respect the dimpled structure of the broad and shallow bituminous basins is reproduced in the narrow and deep anthracite basins.

The crushing, sidewise thrusting action from the south against the Anthracite coal region is admirably illustrated by this model, which is only the first of a series, to be extended lengthwise of the Mahanoy and Shamokin field as the Geological Survey advances.

Stated Meeting, December 3, 1880.

Present, 19 members.

President, Mr. FRALEY, in the Chair.

Letters of envoy were received from the Royal Observatory, Greenwich, Dec. 1880; and the Board of Commissioners of the 2d Geological Survey of Penna., Harrisburg, Nov. 25, 1880.

Donations for the Library were received from the R. Accademia dei Lencei, Rome; Zoologischer Anzeiger, Leipsig; Geographical Society, Annales des Mines, and Revue Politique, Paris; Society of Commercial Geography, Bordeaux; R. Astronomical Society, and Nature, London; American Academy of Medicine, and Editors of the International Review, New York; Academy of Natural Sciences, Medical News, Engineers' Club, Journal of Pharmacy, and Geo. Hamilton, M. D., Phila.; and the Board of Commissioners of the 2d Geological Survey of Pennsylvania.

A letter from Mrs. Haldeman, enquiring about the memoir and relics for illustration by the late Prof. Haldeman was read, and on motion it was

Resolved, That the Curators be authorized to deposit the cards on which these relics are arranged, in the Museum of the Academy of Natural Sciences, and to take a receipt for the same, as in the case of other curiosities belonging to this Society there deposited.

The death of Prof. Jas. C. Watson, at Madison, Wis., Nov. 23, 1880, aged 41, was announced by the Secretary.

A communication entitled: "On the Vertebrata of the Wind River Eocene beds of Wyoming. By E. D. Cope," was read by title.

Dr. König exhibited two specimens of silver ore from near Ouray, in Colorado, of unusual interest as exhibiting the reduced native silver and also the asphalt (enclosed in calcite) by which it had been reduced.

The Treasurer's annual report was read and referred.

The Publication Committee reported verbally that they had approved the plates for Prof. Haldeman's Memoir.

The Committee on the communication x, y, z, for the Magellanic Premium reported; and on motion the following resolutions were passed:

Resolved, firstly, It appearing that the communication of x, y, z, for the Magellanic premium relates to mechanical devices not immediately pertaining to Navigation, Astronomy, or Physics, it is not proper that the question of merit or worthiness of the invention, discovery, or improvement set forth should be passed upon by this Society.

Resolved, secondly, That the Secretaries be authorized and empowered to allow the withdrawal of this communication by any person who, they may become satisfied, has the right to withdraw the same, and that the Secretaries be directed to assure such person that the Society commits itself to no opinion in any way derogatory to the invention, discovery, or improvement, but simply finds the same not to relate to the subjects prescribed by Magellan, or those upon which premiums are to be awarded.

Pending nominations Nos. 909, 920 to 925, and new nomination No. 926 was read.

The resolution offered by Dr. LeConte, at the last meeting, was then considered, and there being present the lawful number of 3 members of the Board and Council, and 13 members of the Society necessary for a change in the By-Laws, after due public notice given, was unanimously adopted.

Resolved, That the concluding clause of the first paragraph on page 17 of the By-Laws, *i. e.*, all after the word "premium" in the 5th line of that page, be struck out, and the words "for such purposes as may be authorized by its charter and laws" be substituted therefor.

The other three resolutions recommended to the consideration of the Society were on request again postponed to allow time for the members of the Society to become better acquainted with their tenor.

1. *Resolved*, That the members of the Society be invited to send to the Secretaries the names of notable discoverers in any branch of science, or the fine or useful arts, with the reasons for bestowal of medals for their discoveries.

2. *Resolved*, That such names and recommendations be placed for consideration in the hands of the President to report to the Society his verdict in favor of one or more of them if proper.

3. *Resolved*, That, in case no veto is placed by the Society on such verdict, there shall be a presentation of medals to the persons recommended by the President at a time and in a manner to be arranged by him.

And the meeting was adjourned.

Stated Meeting, *Dec.* 17, 1880.

Present, 10 members.

Vice-President, Mr. Price, in the Chair.

Mr. J. B. Townsend accepted by letter his appointment to prepare an obituary notice of the late Henry Wharton.

A letter respecting duplicates was received from H. B. Dawson, Morrisania, N. Y.

A circular was received from the Peabody Academy of Science, at Salem, Mass.

Donations for the Library were received from the Asiatic Society of Japan; the Berlin Academy; the Verein für Beförderung des Gewerbfleisses, Berlin; Zoologischer Anzeiger, Leipsig; Naturhistorisches Verein, Bonn; Revue Politique, Paris; Revista Euskara, Pamplona; Nature, the Nautical Almanac Office, and Dr. C. Wm. Siemans, London; R. Dublin Society; Yale College, and the American Journal, New Haven; Franklin Institute, Commissioners of the New Public Buildings, and Mr. Henry Phillips, Jr., Philadelphia; Hon. Lane S. Hart, State Printer, Harrisburg; Johns Hopkins University, Baltimore; U. S. Geo-

logical Survey of the Territories; and the Ministerio de Fomento, Mexico.

Two pieces of slag from the site of the earliest iron furnace in Virginia was presented to the cabinet by Mr. Phillips, for Mr. R. Alonzo Brock.

Prof. Cope was, on motion, permitted to withdraw for immediate publication elsewhere his communication on the Vertebrata of the Wind River Eocene beds, the principal features of which he described, and exhibited the lower jaw of *Bachyopsis hiscidens* in illustration of the extraordinary character of these fossils. Of 46 species studied, 26 species (and 3 genera) are new. The collection is specially important as placing the Wind River beds (hypothetically) between the Bridger beds above and the Wasatch beds below, types peculiar to each being found mingled in it.

Mr. Lesley read extracts from a letter from Mr. Andrew S. McCreath, Chemist in charge of the State Geological Labratory at Harrisburg, giving an analysis of a *pure* dolomite exposure, in mass, in Franklin county.

HARRISBURG, Dec. 10, 1880.

"While selecting samples of the iron ores in the Mt. Alto district, Col. Wiestling showed me a limestone quarry or opening which, on one of your visits, you thought was partly unaltered blue carbonate of iron, with possibly 18 to 20 per cent. metallic iron. Samples were carefully selected—201 pieces for sample—and analysed with the following results:

Carbonate of lime	51.748	
Carbonate of magnesia	43.436	
Carbonate of iron	.665	= 0.321 % iron.
Alumina	.222	
Sulphate of lime	.046	
Phosphate of lime	.065	
Silica	4.090	
	100.267	

"Calculating the carbonates of lime and magnesia to 100 parts we get the following as compared with a true lithological dolomite:

	Shiery Quarry, Mt. Alto.	Dolomite.
Carbonate of lime	54.36	54.35
Carbonate of magnesia	45.64	45.65
	100.00	100.00

"I find this extremely interesting, for it is the only *true* dolomite I have yet found in such large quantity in this State."

Also notes by Prof. I. C. White, Asst. Geologist and Professor of Natural History in the University of West Virginia, stating his conclusions respecting the distribution of the members of the Conglomerate in Western Pennsylvania.

Mr. Lesley exhibited an index guage which he had had constructed by Messrs. Young, of Philadelphia, for the use of the Survey, and showed a small topographical model in wax which had been made by means of it.

The Treasurer read the report of the Committee on Finance.

On motion, the appropriations recommended by the Committee were passed.

The report of the Trustees of the Building Fund was read by the Treasurer.

On motion of Mr. Lesley, the Committee on Publication was authorized to issue the articles published in the Transactions, separately, or together, at their discretion.

And the meeting was adjourned.

Notes on the Place of the Sharon Conglomerate in the Palæozoic Series. By Prof. I. C. White.

(*Read before the American Philosophical Society, Dec. 17, 1880.*)

With regard to the place of this rock in the series, about which there has been much diversity of opinion among geologists, I have to say that my study of it and its associated rocks during the past season in this district,* as well as in Venango and Warren counties, to the east, and in the State of Ohio to the west, has dispelled the idea that I at one time entertained of the possibility of its being the Vespertine Conglomerate, or No. X of Rogers, and has confirmed me in the position that I took in my reports Q and QQ on Beaver and Lawrence counties, viz: that it is the true base of No. XII.

It may be of interest to state here the reasons which caused me to entertain such a possibility.

It happened that during my season's work in Mercer county in '78, I discovered a new limestone in the Mahoning river, only about 50′ above the horizon of the Sharon Conglomerate, and nearly 100′ below any limestone hitherto known in Western Pennsylvania. It was filled with fossils and some of them seemed to be related to Subcarboniferous types.

*These notes were written for the Report of Progress of the Survey in Erie and Crawford counties. J. P. L.

By a singular fatality, it also happened that the supplemental Report of Prof. Orton on the Hanging Rock district of Southern Ohio came into my hands at about the same time.

It is well known that in the Report in question Prof. Orton takes the ground (in which he was also sustained by the Chief Geologist, Prof. Newberry), that the *Jackson shaft coal* of that State is of *Subcarboniferous age,* since, as he maintained, its place comes below the horizon of the Maxville (Chester) Limestone of Andrews, and as the *Maxville* was placed in the section about 100′ above the *Jackson shaft coal,* I supposed there could be no doubt about it.

I also knew that wherever the Jackson shaft seam was placed, the *Sharon* must go with it, since the general stratigraphy, the flora connected with each, and everything else found in connection with them go to prove that they are identical.

Then the fact that Prof. Orton placed the *Maxville Limestone* the same distance below the *Zoar Limestone* (= our Lower Mercer) that I had found the *new limestone* below our *Lower Mercer,* strengthened the supposition that it might be synchronous at least with the Maxville.

And in order to bring out these new facts, I prepared a special chapter for my Report on Mercer county, QQQ, entitled "The Place of the Sharon Coal in the Rock Series," in which the facts were given that seemed to favor the view that the *Sharon Coal* was of *Subcarboniferous age,* and the Conglomerate below it, *Vespertine.*

Before the volume was published, however, I had studied the matter still farther in the Crawford and Erie district, as well as elsewhere, and as before stated, saw reasons for the giving up the probability of its Subcarboniferous age. I accordingly requested Prof. Lesley to suppress the chapter in question, as its publication at that time would have done more harm than good. Hence QQQ was allowed to leave the press with Chap. VII stricken out. In the meantime Prof. Orton has written me that he will have to give up the position that he took in Vol. III, of the Ohio survey with regard to the *Subcarboniferous age* of the *Jackson shaft coal,* and with that abandoned there remains so little evidence that the *Sharon coal* is *Subcarboniferous,* that for the present it is not worth serious consideration.

The foregoing explanation is relevant in this connection because of the currency given in Prof. Lesley's preface to QQ, to the views expressed in the afterwards discarded Chapter VII, of QQQ.

But while it thus appears that the *Sharon Conglomerate* is the true base of the Carboniferous epoch proper, it must also be remembered that like the *Sharon coal* resting on its top, it seems to have been a deposit peculiar to the *northern rim* of the Coal measures, everywhere skirting them around the north, but seldom passing far south under them, so that although toward the north the succession is definite enough, and it is plainly seen that the *Subcarboniferous rocks* end with the base of this stratum, yet toward the south in the absence of this rock the Subcarboniferous beds, with their fossils, extend

up to the base of the *Sharon coal*, and in the absence of that deposit, also extend to the very base of the *Lower Connoquenessing Sandstone* which then becomes the base of the *Conglomerate series.*

Thus it is that in passing south along the Shenango and Mahoming rivers into Lawrence county, the *Cuyahoga shale*, and its fossils, are found coming up to the base of the Lower Connoquenessing Sandstone.

It follows from this northward distribution of the Sharon Conglomerate, that the marine conditions that had so widely prevailed during the closing period of the Subcarboniferous epoch, so far as Western Pennsylvania is concerned, came to an end sooner around the northern margin of the present coal field than elsewhere, that to the south, marine conditions continued to prevail, while on the northern beaches, brought above or near sea-level either by greater rising or less rapid subsidence, the Sharon Conglomerate commenced to accumulate, and continued to do so during the long time that marine conditions still obtained to the southward; finally however the incursion of the coarse sediments of the *Connoquenessing Sandstone* destroyed the life in the shallow seas southward, and so far as we know this put an end to Subcarboniferous life and conditions in Western Pennsylvania, that had already been forced a considerable distance southward by the incursion of the disturbing currents which carried the coarse material of the Sharon Conglomerate. It may even have happened that still farther south along the Chestnut Ridge region where subsidence was greater, that the marine conditions of the Subcarboniferous epoch continued to exist until the great incursion of coarse sediment which formed the *Homewood Sandstone* and completed the *Conglomerate series*, and this indeed seems in some regions to have actually been the state of affairs since in Fayette and Westmoreland counties, Pa., and in the adjoining county of Monongalia, W. Va., the only member of the series present in any force is the Upper, or *Homewood*, and it is 175′–200′ thick. There is nothing at all to represent the *Sharon Conglomerate* of the north, and the interval between the *Umbral Limestone* and the *Homewood Sandstone* is made up of reddish and greenish shales interstratified with green sandstones which look more like *Subcarboniferous rocks* than any representatives of No. XII that I have ever seen. And in fact at times this Homewood Sandstone itself appears absent or in little force, and then the red shales of the Umbral continue up to the very base of the *Lower Productive Coal measures.*

Hence, if am correct in this interpretation of facts, it will not do to draw a hard and fast line at any place in the series and say that every thing *above* it is *Carboniferous* and everything below *Subcarboniferous*; for as well as we can unravel the history in Western Pennsylvania, it would seem that the Sharon Conglomerate at least, was in process of formation and synchronous with marine conditions prevailing farther south, essentially similar to what had existed at the north previous to the change in conditions which rendered the accumulation of that mass of coarse sediment possible, and that subsequently the changed conditions at the north were carried farther and farther south with each great incursion of coarse material until

finally the period culminated and ended by the spread of the Homewood Limestone as an almost universal covering over Western Pennsylvania.

After this final castastrophe scarcely any of the life forms that had existed before the accumulation of the Sharon Conglomerate remained, though the process of extinction and change had been progressive toward the south from the beginning.

On this theory only, so far as I can see, can we explain the results at which Mr. Platt of the Survey Corps seems to have arrived from the study of the rocks to the south-east in Jefferson, Indiana and Armstrong counties, viz: that the rocks of No. XI (Subcarboniferous) extend up to the base of the *Homewood Sandstone*, and that *it* is the only member that can be properly placed in No. XII.

In such localities where Subcarboniferous conditions seem to have existed until the epoch of the Homewood Sandstone, or top member of the Conglomerate series, it would certainly be unwise to include any lower beds in this series, and yet it seems to me equally wrong to draw the line along the base of the *Homewood Sandstone* in such a case and extending it over wide areas, call everything below it Subcarboniferous.

It is a question of time against conditions. If it be right to call all rocks *Subcarboniferous* that were formed everywhere and under any surroundings until Subcarboniferous conditions had closed everywhere then it would undoubtedly be correct to draw the line squarely at the base of the Homewood Sandstone; but under the broader view that discards cataclysmal changes in the Earth's history, and recognizes the now well proven fact that almost all great changes have been gradual and progressive, and that to be so they must have had a beginning somewhere in the midst of widely differing conditions, recognizing this principle it seems to me there should be no hesitation about extending the line downward from the base of the Homewood Sandstone, as we proceed north, under the feather edges of these northern Conglomerates, until we reach the base of the Sharon Conglomerate, even if this latter stratum were coëtaneous with the deep sea that prevailed along the south line of Western Pennsylvania during the Chester limestone epoch, for all these conglomeratic sandstones, from the base of the Sharon to the top of the Homewood, were formed under similar conditions, and the Subcarboniferous sea at no time returned northward to restore the life forms which the appearance of the Sharon Conglomerate had driven away forever. To do otherwise than this would be equivalent to classifying the marine deposits which are now taking place along the coasts of this country and Europe with the Cretaceous, because perchance Cretaceous life and conditions may now exist in the deep bed of the Atlantic.

I have discussed this matter somewhat at length, hoping to throw some light upon and help to harmonize the hitherto conflicting results of all who have undertaken the study of this question. It is certainly a difficult subject to deal with, but it seems to me that we have now got hold of some of the threads at least, out of which the true history of the fabric can be woven.

Mr. Lesley said, in presenting these notes, that he considered every field geologist entitled to the expression of his opinions, but that only such as worked over the whole field, and knew precisely all the facts in every part of it, would be likely to see a clear way to the final resolution of its difficulties. These difficulties cannot be resolved on the Ohio side of the coal field alone; nor on the Alleghany Mountain side of it alone; nor by even an exhaustive observation in the north, nor by an exhaustive discussion of them in the south. If there *be* "a northern rim" to the ancient coal field, there must have been an eastern and a southern and a western one also; and no generalization will avail that does not satisfy the data all around the compass—and in fine, also, all over the interior area, where unfortunately we have very few opportunities for study.

These difficulties are set forth in the preface to Mr. Platt's report H 5 on Armstrong county, in which the same suggestion of an overlapping of the upper divisions of No. XII is made which Prof. White makes in these notes. But it is there shown that the exhibition of No. XII along the Alleghany mountain, and in Maryland and Virginia, as well as in the northern counties, and in the Anthracite coal region of our own State, is not such as can be entirely explained by the suggestion; which has its value; but which must be cautiously followed as a guide in classification.

The combined labors of half a dozen geologists, all equally competent as observers and theorizers—labors pursued unremittingly now for half a dozen years—have not yet sufficed to procure all the light we need to have thrown on the synchronomy of even our own Pennsylvanian Carboniferous and Devonian deposits; and every fresh survey in a new district like that of Mr. Jones in Maryland, and that of Prof. Stevenson in Southwest Virginia, serves, among other things, to throw doubt upon the shifting generalizations in which too many otherwise judicious geologists are prone to indulge—reversing the directions in which we look for the

original sources and maxima of deposits—shortening the radii of areas of violent variations, and even of nonconformability—and embarrassing the best laid plans for restoring the state of things in ancient days.

Photodynamics. By *Pliny Earle Chase, LL.D.*

(*Read before the American Philosophical Society, Jan. 7, 1881.*)

The general laws of motion have been largely studied in connection with the special departments of Thermodynamics and Electrodynamics. Little attention has been paid, comparatively speaking, to the much broader field of Photodynamics.

Sir John Herschel showed* that the elastic force of the air, in its resistance to compression, would require to be increased, "*in proportion to the inertia of its molecules,*" more than 1,000,000,000,000 fold to admit of the propagation of a wave with the velocity of light, and that this enormous physical force is perpetually exerted at every point, through all the immensity of space. He also said†: "It must be remembered that it is LIGHT, *and the free communication of it from the remotest region of the universe,* which alone can give and does give us the assurance of a uniform and all pervading energy." We have no equally positive evidence of the direct transmission of heat and electricity from the heavenly bodies, and inasmuch as all thermal and electrical phenomena can be explained by local transformations of simple radiant energy, the philosophical basis of Photodynamics appears to be better grounded than that of either Thermodynamics or Electrodynamics.

In 1863, I began a series of general kinetic investigations, in confirmation of views which may be expressed by the following general postulate: *All physical phenomena are due to an Omnipresent Power, acting in ways which may be represented by harmonic or cyclical undulations in an elastic medium.* In my first paper‡ I showed the importance of the fundamental equations $v = \frac{gt}{2}$; $h = \frac{gt^2}{4}$ the *modulus* of v; in which t represents the time of cosmical, molecular, or atomic rotation, and g represents the acceleration of a central force.

By combining these equations with considerations derived from the equality of elastic actions and reactions proportioned to mass, and from tendencies to conservation of areas, I found that the daily and annual fluctuations of the barometer furnish harmonic indications of Sun's mass and distance, and I announced my confident expectation of other astronomical

* Familiar Lectures on Scientific Subjects, pp. 281–3

† Ib. p. 218.

‡ Proc. Am. Phil. Soc., vol. ix, pp. 283–8.

verifications or rectifications by means of varying pressures.* In the following year I introduced the hypothesis, which has since been largely developed by Edlund, that electricity consists simply of æthereal vibrations.† In confirmation of this hypothesis, I showed that many of the phenomena of terrestrial magnetism can be produced by simple mechanical vibrations, resembling those of the atmospheric currents which arise from the combined action of terrestrial rotation and thermal convection.‡ In connection with these investigations I called attention to the importance, and some of the probable consequences, of radial and tangential oscillations *moving with the rapidity of light*,§ and of their bearing upon "the phenomena of light, heat, electricity, polarity, aggregation, diffusion, meteorological changes, seismic tremors, crystallization, stratification, chemical action and general morphology."‖

My discovery of numerous numerical relations between gravity and magnetism, for which the American Philosophical Society awarded its Magellanic medal, led me to seek, in the maximum manifestations of gravitating force, the correlation of gravity with other forms of energy, for which Faraday** had looked confidently but in vain. The greatest gravitating force in our system and, therefore, the greatest of which we have any direct and positive evidence, is at Sun's surface, where material particles are subjected to such oscillations as may arise from the conflicting centripetal energies of solar attraction and of the resultant attraction of all other cosmical bodies. In applying the fundamental equation, $v = \frac{gt}{2}$, at Sun's surface or the locus of maximum gravitation, I found that the equality of action and reaction, as shown by the sum of the solar-central gravitating reactions against the sum of the gravitating actions towards the centre of the solar system, in the cyclically alternating thrusts and pulls of half-rotation, *is represented by the velocity of light*.†† This discovery, together with the identification of the same velocity as a factor of electro-magnetic action, which was completed and confirmed by the investigations of Thomson and Maxwell, brought all physical phenomena, cosmical as well as molecular, within the domain of Photodynamics.

The molecular phenomena may be readily connected with the cosmical, through the correspondence between Challis's laws of molecular action and the laws of attraction and rotation.‡‡ They furnish grounds for estimating Sun's mass and distance by means of the explosive energy of hydrogen;§§ for discovering some of the subordinate elements of planetary arrange-

* Ib. ix, 288; x, 376.

† Ib. ix, 355–60.

‡ Ib. ix, 367-71, 425–40, 487-95; x, 97-118, 151-60.

§ Ib. ix, 408-11.

‖ Ib. ix, 480.

** Exp. Res., 2814.

†† Proc. Am. Phil. Soc., xi, 103 7.

‡‡ Ib. ix, 367-71.

§§ Ib. xii, 392-4.

ment;* for a mathematical deduction of the ratio (1.4232) between the mean *vis viva* of gaseous volume (*heat under constant volume*) and the *vis viva* of uniform velocity (*heat under constant pressure*);† for finding an identity of law in luminous and planetary nodes;‡ for a cosmical determination of Joule's equivalent;§ and for connecting the molecular velocities of gaseous particles with the velocities of terrestrial rotation and revolution.‖

Although many of the stellar motions indicate the probability of gravitating action, in other systems than our own and between different systems, no direct, positive and measurable evidence of such action has yet been found. Gravitating and elastic forces may, however, be numerically compared, through the common equation of wave and orbital velocity, $v = \sqrt{2gh}$, in which h represents the height of virtual fall which would give the required velocity, or $\frac{1}{2}$ the height of a homogeneous atmosphere, or $\frac{1}{2}$ the radius of a circular orbit, or the focal distance in a parabolic orbit. In consequence of the tendency of nodal points, in any vibrating elastic medium, to produce harmonic vibrations and harmonic nodes of various kinds, we may reasonably look for such nodes as results and evidences of interstellar action.

Among the various gravitating, paraboloidal and harmonic wave influences, which have been instrumental in world building, the following seem specially noteworthy:

α. The principal centre of nucleation in the solar system, which is represented by the Sun.

β. The principal centre of condensation, which is represented by the Earth; Mercury's secular perihelion being .2974,¶ and the secular aphelion of Mars being 1.73648, the middle of the dense belt of planets is 1.01694, which is midway between Earth's mean distance and mean aphelion (1.03387).

γ. The principal nebular centre of the system, which is represented by Jupiter's mean aphelion; Neptune, the aphelion planet, being 30.03386, and Uranus, its corresponding perihelion planet, being 19.18358, the nebular centre is 5.42514. Jupiter's mean aphelion is 5.42785.

δ. The linear centre of oscillation of a solar diameter ($\frac{2}{3}$), which gives $\frac{1}{3}$ radius as a directrix of paraboloidal influence, and $\frac{1}{6}$ radius as the abscissa of the paraboloidal vertex.

ε. The ratio $(\frac{1}{6})^2$, between the solar central force at the paraboloidal vertex and the corresponding force at Sun's equatorial surface.

ζ. The ratio of dissociative subsidence $\left(\frac{nr}{n+1}\right)$. If we take the radius of a nebula as a fundamental node, the velocity which would be acquired

* Ib. xii, 403, seq.
† Ib. xiv, 651.
‡ Ib. xvii, 109-12.
§ Ib. xviii, 20-1.
‖ Ib. xviii, 21-5.
¶ The values are taken from Stockwell, *Smithsonian Contributions*, 232.

by a body in falling from a distance nr to any other distance x may be found by the equation, $v\,dv = gr^2x^{-2}d\,(nr-x)$; integrating and reducing, $v = \left\{\frac{2\,gr\,(nr-x)}{nx}\right\}^{\frac{1}{2}}$. If this velocity is due to a synchronism of activity, between nebular condensation within any given stellar system and parabolic projection between different systems, $v = \sqrt{2gr}$; $\frac{nr-x}{nr} = 1$; $x = \frac{nr}{n+1}$.

η. If $n = 2$, $\frac{n}{n+1} = \frac{2}{3}$. This corresponds with the centre of linear oscillation; it is also the locus of belt formation, on account of the collision of subsiding particles from opposite extremities of a nebular diameter. In such subsidence there would be a tendency to form confocal elliptic orbits,* with major axes of $\frac{3r}{2}$ and minor axes of $r\sqrt{2}$.

θ. In rupturing or explosive oscillation, the *vis viva* of wave propagation is $\frac{9}{5}$ of the *vis viva* of oscillating particles.† This relation was subsequently pointed out by Maxwell,‡ apparently without being aware that I had called attention to it five years previously.

I. Harmonic nodes with the ratio $\frac{1}{9}$, (ε), indicate the primary division of the solar system, as may be seen by the following comparisons, in which r_0 represents Sun's radius:

Theoretical.	Observed.	
$9^2\ r_0 = 81\ r_0$	Mercury	$83.05\ r_0$
$9^3\ r_0 = 729\ r_0$	Asteroid 76	$731.37\ r_0$
$9^4\ r_0 = 6551\ r_0$	Neptune, s. a.§	$6536.91\ r_0$

II. The influence of subsidence (η), at the outer surfaces of the two primitive belts, is shown as follows:

Theoretical.	Observed.	
$\frac{2}{3}$ Neptune $= 20.0226$	Uranus, m. a.,	20.0442
$\frac{2}{3}$ Mars $= 1.0158$	Earth, m. a.,	1.0339

We have already seen, (δ), that the middle of the belt of greatest condensation is 1.0169.

III. The influence of rupturing oscillation, (θ), at the inner surfaces of the two primitive belts, is equally evident.

Theoretical.	Observed.	
$\frac{9}{5}$ Mercury $= .696778$	Venus, m. p.,	.696779
$\frac{9}{5}$ Jupiter $= 9.3650$	Saturn	9.5389

The oscillating limits of all portions of the Jupiter belt are within the Saturnian belt.

* Proc. Am. Phil. Soc., xvii, 98–109.

† Ib. xii, 392–4.

‡ See Phil. Mag., June, 1877, p. 453.

§ s., *secular*; a., *aphelion*; m., *mean*; p., *perihelion*.

IV. The influence of paraboloidal directrices and vertices, (δ), is manifested in each of the primitive belts:

$\frac{1}{6}$ Mars = .2894	Mercury s. p. .2974
$\frac{1}{6}$ Neptune = 5.0068	Jupiter m. p. 4.9782
$\frac{1}{3}$ Neptune = 10.01128	Saturn m. a. 10.00006

The paraboloidal vertex for the whole Neptunian belt is within the Jupiter belt.

V. By introducing Laplace's limit of possible solar atmosphere* ($L = 36.36r_0$), and the ratio, $\left(\frac{\pi}{1 \cdot 2}\right)$, of the fundamental velocity $\left(\frac{gt}{2}\right)$ to the corresponding parabolic velocity $\left(\frac{gt}{\pi \cdot 1 \cdot 2}\right)$, we find the following simple equation of solar and planetary harmonic action at the centre of principal condensation. $\left(\frac{1 \text{ year}}{1 \text{ day}} \times \frac{\text{Sun's semi-diameter}}{\text{Earth's semi-axis major}}\right)^3 = \frac{\pi^2}{2}$. This gives Earth's semi-axis-major $= 214.54r_0$.

VI. The combined influence of centres of nucleation, (α), and of nebulosity, (β), at the centre of condensation, (γ), leads to the following simple harmonic estimate of Sun's mass and distance.

Earth's semi-axis major being $214.54r_0$, the leverage of the paraboloidal directrix is $(214.54 + \frac{1}{3} =)\ 214.87r_0$, and the mean leverage of Jupiter is $(5.202798 - 1) \times 214.54r_0 = 901.668283r_0$. Multiplying by the respective masses, we obtain, for the ratio of Sun's comparative disturbing force at the directrix and at the centre of condensation, $\frac{1047.879 \times 214.87}{1 \times 901.668283} = 249.712$. The superficial nodal force (ε) being $\frac{1}{9}$ as great, we find, for the ratio of Sun's to Earth's superficial gravity, $\frac{g_0}{g_1} = \frac{249.712}{9} = 27.716$. If we designate superficial gravity by g, volume by V, density by d, and mass by m, it is evident that $r \propto (g \div d)$; $V \propto (g \div d)^3$; $m \propto (g^3 \div d^2)$; $d \propto (g \div r)$. Hence we readily get $\frac{d_0}{d_1} = .25523$; $\frac{m_0}{m_1} = \left(\frac{27.716}{.25523}\right)^3 = 327,897$; $\frac{r_0}{r_1} = \frac{27.716}{.25523} = 108.71$; Earth's semi-axis major $= 214.54r_0 = 214.54 \times 108.71 \times 3962.8$ miles $= 92,422,000$ miles.

VII. The solar modulus of light, ($M = 688.82^2 r_0$), furnishes the third element of the parabolic projection which is indicated by the fundamental equation $v = \frac{gt}{2}$. The three elements are all photodynamic, viz: 1. The locus (r_0) of luminous action which makes $\frac{gt}{2}$ equivalent to the velocity of light; 2. The locus (L) of orbital half-revolution which is synchronous with solar half-rotation, the synchronic time being determined by the velocity of light; 3. The locus (M) of radial luminous progression during the same synchronic time of solar half-rotation; M is also the altitude, in

* *Mec. Cel.*, III, § 47.

the fundamental equation $h = \frac{gt^2}{4}$, of Sun's homogeneous ætheral, or light-propagating atmosphere. The values of L and M are found as follows:

The mean time of light-propagation from Sun to Earth being 497.827 seconds, the velocity of light (v_λ) is $214.54r_0 \div 497.827 = .43095r_0$; $v_0 =$

$$\sqrt{g_0 r_0} = \frac{2\pi \times 214.54^{\frac{1}{2}}}{365.256 \times 86400} = .0006235r_0;\ g_0 = v_0^2 \div r_0 = .00000039144r_0;$$

$$\frac{t}{2} = v_\lambda \div g_0 = 1100965 \text{ sec.};\ L = 214.54r_0 \div \left(\frac{\text{half-year}}{1100965 \text{ sec.}}\right)^{\frac{2}{3}} =$$

$$36.36r_0;\ M = \left(\frac{v_\lambda}{v_0}\right)^2 r_0 = 474460r_0.$$

VIII. By introducing the ratio of dissociative subsidence, (ζ), with the general equation $x_n = \xi\eta^n\zeta^{n^2}$, we find a series of paraboloidal abscissas which complete the photodynamic demonstration of a harmonic nodal action, uniting the solar, planetary and stellar systems. Take for the middle abscissa, $\frac{4}{9}$L, and for the limiting abscissas of centripetal action, $\frac{1}{6}r_0$ and LM $\div r_0$. The relative *vis viva*, or the locus of projection against uniform resistance, of the linear centre of oscillation of L, is $\frac{4}{9}$L; $\frac{1}{6}r_0$ is the paraboloidal vertex; LM $\div r_0$ bears the same ratio to M as L to r_0. If we take 18 successive abscissas on each side of the middle abscissa, the logarithms of η and ζ can be readily found by the equation:

$$\text{Log. } \xi = \text{log. } \tfrac{1}{6} = -.778151.$$

$$\text{Log. } \xi + 19 \text{ log. } \eta + 361 \text{ log. } \zeta = \text{log. } \tfrac{4}{9}\text{L} = 1.208452.$$

$$\text{Log. } \xi + 38 \text{ log. } \eta + 1444 \text{ log. } \zeta = \text{log. LM} = 7.230836.$$

Of these 39 abscissas, 9 are between the vertex and $\frac{1}{6}r_0$, the locus of solar dissociative subsidence (ζ): 9 are between $\frac{1}{6}r_0$ and L; 9 are between L and the locus of reciprocal action, which will be presently explained; 9 are between the reciprocal locus and LM $\div r_0$.

The 40th abscissa is $46353000r_0$, (log. 46353000 = 7.666079). This is in the region of the fixed stars, and at the probable locus of *α Centauri*, the four most recent estimates of its distance ranging between $45840000r_0$ and $48479500r_0$. Both in the centripetal and centrifugal branches of paraboloidal action, 12 of the abscissas are between Sun's centre and surface; 9 are between Sun's surface and the planetary region; 9 are in the planetary region; 9 are between the planetary region and *α Centauri*.

Dividing the planetary abscissas by 214.54, in order to reduce them to terms of Earth's semi-axis major, we find the following accordances:

n.	Centripetal abscissas.	Planetary loci.		n.	Centrifugal abscissas.	Planetary loci.	
21	.2095	☿ Mercury	.1985	—21	.2494	Mercury s. p.	.2974
22	.3632	♀ Venus	.3617	—22	.4362	Mercury m. a.	.4555
23	.6459	⊕ Earth m. p.	.6441	—23	.7820	Venus s. a.	.7744
24	1.1788	♂ Mars	1.1424	—24	1.4392	Mars m. p.	1.4082
25	2.2080	Asteroid 55	2.2080	—25	2.7179	Asteroid 45	2.7200
26	4.2432	♃ Jupiter	4.3357	—26	5.2666	Jupiter	5.2028
27	8.3678	♄ Saturn	8.1762	—27	10.4720	Saturn s. a.	10.8438
28	16.9309	♅ Uranus	16.7857	—28	21.3662	Uranus s. a.	20.6792
29	35.1523	♆ Neptune	35.0395	—29	44.7332	♆ Neptune m.p.	44.5985

Both in the centripetal and in the centrifugal abscissas, Neptune indicates a reciprocal action, as if from a joint solar and stellar tendency, the solar preponderating. The centripetal co-efficient ($\frac{7}{8}$) is reciprocal to that of Saturn ($\frac{8}{7}$), Saturn's orbit embracing the primitive centre of rotating inertia for the planetary portion of the nebula ;* the centrifugal co-efficient ($\frac{3}{2}$) is the reciprocal of Earth's centripetal co-efficient ($\frac{2}{3}$).†

All the centripetal abscissas represent loci of nebular subsidence, (ζ), which would communicate velocities equivalent to the corresponding solar-stellar parabolic velocities.

All the centripetal abscissas, except Earth's, correspond most nearly with mean planetary loci ; Earth's abscissa represents mean perihelion, or the mean locus of maximum velocity, which is also the locus of belt formation (η) in a nebula extending to Earth's mean perihelion distance. This may account for the number and simplicity of the harmonic relations which I have pointed out, between Sun's mass and distance and barometric pressure, heat distribution, terrestrial magnetism, thermodynamic *vis viva*, terrestrial gravitation, æthereal and atmospheric inertia, specific gravities, explosive energies, terrestrial rotation, lunar distance, lunar revolution, planetary eccentricities, cosmical masses, nebular condensation, dissociation and aggregation, spectral lines, thermal equivalence, atomicity, chemical affinity, velocity of sound, and velocity of light.

Since these results are derived from the hypothesis of equal gravitating and æthereal action and reaction, we may infer that the density of the luminiferous æther, at Sun's surface, is $\left(\frac{r_0}{M}\right)^2$ of the Sun's density, or $\left(\frac{5.5 \times .2\dot{5}585}{474460^3} \times \frac{778}{.0693} =\right) \frac{1}{6821000000000}$ of the density of hydrogen.

* Proc. Am. Phil. Soc. xii, 405 ; xviii, 481.

† See also Ib. xviii, 231.

4 S
.
.531
.92

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIX. JANUARY TO JUNE, 1881. No. 108.

TABLE OF CONTENTS.

Note. Six plates of the figs. described on page 58 (received too late to be bound with No. 107) are bound with this No. 108.

ERRATA.

Page 301, l. 27, read, continued *in* this channel, &c.

Page 301, ¶ 5, 5, read ¶ *5a*, *5b*.

Page 310, l. 10, read *Brant* for Brent.

Page 311, footnote, read *south*ern and *south*-western for northern and north-western.

Page 318, l. 31, read connection *with* Lake Huron.

Page 319, l. 5 from bottom, read *have been* excavated.

Page 323, l. 33, read lake *at* no very great distance.

Page 328, l. 34, read valley *from* Lake Erie.

Page 332, l. i., read westward, *it has* about.

Page 333, l. 16, read, refer *to* some buried, &c.

Page 352, *J.* F. Mansfield should read *I.* F. Mansfield.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA.

VOL. XIX. JANUARY TO JUNE, 1881. No. 108.

Stated Meeting, January 7, 1881.

Present, 8 members.

President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were read from the Morganländische Gesellschaft, Halle a. S., Nov. 30 (100 to 105; list), and from Prof. J. J. Stevenson (106).

A letter requesting exchanges was received from M. DeMilloux, Director of the Musée Guimet, Lyons. On motion, it was referred to the Committee on Publication with power to act.

A request from the Albany Institute for No. 101 to complete a set was allowed.

Donations for the Library were received from the Russian and Belgian Academies; the Flora Batava; the Geographical Societies in Paris and Bordeaux, London Astronomical and Meteorological Societies and Nature, Nautical Almanac of Spain, American Journal of Mathematics, Silliman's Journal, Dr. G. W. Hawes, the Wesleyan University, New Jersey Historical Society, Pennsylvania Board of Agriculture, H. C. Baird, H. C. Lewis, H. Phillips, Jr., O. T. Mason, and Smithsonian Institution.

An obituary notice of Peter McCall, was read by Mr. Henry Phillips, Jr.

Notes on Photodynamics, were read by Professor P. E. Chase.

A note on the protection of oil-tanks from lightning stroke, by B. Howard Rand, M.D., was communicated through Dr. Greene.

Extracts were read from letters of Harrison Wright, Ph.D., respecting the Permian shells discovered in the highest strata of the Wilkesbarre anthracite basin by Dr. Charles F. Ingham, and referred to by him in his forthcoming History of Luzerne county.

The discovery by Prof. Spencer, of King's College, Nova Scotia, of a buried channel, following Grand river, deep enough to permit the preglacial drainage from Northwest Pennsylvania and Western New York to pass across Lake Erie and pass round into the head of Lake Ontario, was described by Mr. Lesley, and its importance insisted upon.

A colored model of the preglacial channel of the Clarion (Allegheny) river in Armstrong county, Pennsylvania, was exhibited.

A colored MS. map of parts of Lee, Wise and Scott counties, Virginia, by Prof. J. J. Stevenson, was communicated for the Proceedings. It continues (westward) and in part corrects the colored geological map of Scott, Russell and Tazewell counties, by J. P. Lesley, published in Volume X of the Proceedings, 1872.

A small map of Pennsylvania was exhibited, colored, to show the progress of the Geological Survey since 1874.

The report of the judges of the annual election was read, declaring the following officers duly elected for the ensuing year:

President.

Frederick Fraley.

Vice-Presidents.

Eli K. Price, E. Otis Kendall, John L. LeConte.

Secretaries.

Pliny E. Chase, George F. Barker, Daniel G. Brinton, J. P. Lesley.

Curators.

C. M. Cresson, Henry Phillips, Jr. George H. Horn.

Treasurer.

J. Sergeant Price.

Councillors for three years.

Daniel R. Goodwin, W. S. W. Ruschenberger,

Henry Winsor, William A. Ingham.

The meeting was then adjourned.

Obituary Notice of Peter McCall. By Henry Phillips, Jr.

(Read before the American Philosophical Society, January 7, 1881.)

The life of a lawyer whose heart was not hardened by the arduous duties of his career, but which, through threescore years and ten, never failed to respond to the calls of humanity; who passed along earth's pathway from the cradle to the grave, untainted by sordid ambitions or ignoble aims; in whose footsteps it would be an honor to tread, whose approbation would be a hall-mark to those fortunate enough to win it—the life of such a man is not written in sand. Such a man is an honor to his profession and to his city. Such a man was Peter McCall.

Peter McCall was born in the city of Philadelphia, on the 31st day of August, A. D. 1809, and departed this life at his summer residence, Overbrook, near Philadelphia, on the 30th day of October, A. D. 1880. He was descended from one of the oldest families in Pennsylvania, an account of whose genealogy is given in the Shippen Papers, edited by Mr. Thomas Balch. His father, also named Peter McCall, intermarried with Sarah Gibson, of whom were born John Gibson (born 1804, married at Tampico, Doña Josefa Beccerra), Charles Archibald (born 1806), Anna Maria (born 1807), and Peter, the subject of the present sketch.

Mr. McCall's education was commenced in Philadelphia, and completed at Princeton, where he graduated with distinction in the class of 1826. He then began the study of the law in the office of Hon. Joseph R. Ingersoll, surrounded by fellow students, who all in later years rose to high legal eminence, and some of whom have occupied the judicial station. Pursuing his studies with zealous assiduity, he was admitted to the Philadelphia Bar on the first day of November, A. D. 1830, and from that day, until a few months since, when increasing infirmities compelled him to relinquish the practice of his profession, his career of usefulness was untiring and unceasing. Had he lived but one day longer, he would have completed a full half century of active work, an event which the Law Association of this city, of which he had been for years a prominent member, and in which he had held the office of Chancellor from 1873 to the day of his death, was preparing to celebrate in an appropriate manner. Upon the walls of its library hangs an excellent portrait of Mr. McCall, painted by Uhle, which a few years since was presented to the Association by the Chancellor's former office

students. His predecessors in that honorable position had always been like himself, men of the highest rank, whose names the lawyers of the entire land were accustomed to utter with veneration, respect and esteem; Rawle, Duponceau, Sergeant, Binney, Ingersoll and Meredith. Names to be handed, with the best traditions of the Bar, down to its latest days.

In 1846, Mr. McCall married Jane Byrd Mercer, at Cedar Park, West River, Maryland, the residence of her father, Col. John Mercer. Of this marriage were born Catherine, John Mercer, Edith (married to Dr. John M. Keating, of this city), Gertrude, Richard Cadwalader, Robert Kemble, Jane Byrd and Mary. Of these children only the youngest daughters survive, to mourn with their mother their great loss. During the years 1837, 1853 and 1870, Mr. McCall traveled in Europe, storing his mind with the rich harvests of Old World knowledge, while enjoying a brief respite from his arduous labors.

Although no politician, in the now-a-days sadly abused signification of the term, Mr. McCall always felt deep interest in the progress of public affairs, and never shrank from accepting such duties as it pleased his fellow-citizens to call upon him to undertake. He sat in the Councils of the City for several terms, and in 1844 was elected Mayor of the City, as the candidate of the Whig party, defeating by a large vote Samuel Badger, the Democratic, and E. W. Keyser, the Native American candidate. This was to Mr. McCall, a great compliment, paid in a time of strong political excitement by the citizens, who understood and appreciated sterling honor and integrity.

On the 18th day of April, 1851, he was chosen a member of our Society, but owing to the continual pressure of other duties, never took an active part in our labors.

He was for many years one of the Trustees of the University of Pennsylvania, in whose law schools, he, until comparatively recently filled the chair of practice, pleading, and evidence.

Mr. McCall was for a time a member of the Vestry of Christ Church (Protestant Episcopal), and also Warden, but after long and faithful services rendered by him to the cause of religion and of the Church, in the early days of the war, his connection with it came to an end.

While the public record of Mr. McCall's life is mainly that of a professional man, yet he was a cultured scholar of refined tastes and great attainments. But he very rarely permitted himself to be seduced by the fascinations of the lighter sciences from the pursuit of the life-long duties to which he had dedicated his career. He knew that the law was a jealous and exacting mistress, in whose service there could be no loitering by the wayside or stepping from the beaten track to cull the flowers of literary success; that it required the devotion of a lifetime, sharing no divided attention, brooking no divided empire. The chief occasions upon which Mr. McCall would permit his literary talents to be observed, were in obituary addresses upon deceased members of our Bar, which he delivered by request, from time to time, in accordance with the kindly usage of the

profession, and his special gifts of eloquence and good taste on such occasions, were always exhibited to great advantage.

He delivered, however, some orations, which have been published, and are all distinguished by a vigorous and elegant style,* clear thought and polished judgment.

Prominent in Mr. McCall's character were his kindliness, gentleness and loving heart. As Judge Hare well remarked,† "he was one of those exceptional men whom nature seems to have formed for virtue, and who are endowed by her with graces which others derive only from education, or through the influences of philosophy and religion. His distinguishing characteristics were singleness of purpose, an entire purity of heart and life, a gentleness that neither took nor gave offence; a charity large enough to embrace all mankind; an instinctive aversion to whatever was low or base; an intuitive perception of the line of right. * * * * He was in short one in whom the various attributes of goodness were so nicely blended in a harmonious whole that he seemed less than he really was; and it may be said of him, as it was of Washington, that he would have been greater in the world's eye had he been less virtuous."

In his earliest life he had set before himself a standard of virtuous excellence to which he proposed to attain, and below which he should never descend. He wrote in his diary upon the nineteenth anniversary of his birthday, "The prospect is fair. May it never be clouded by dishonor or the consciousness of having done an ill deed."

Throughout all the trials, great and small of daily life, he remained true to his principles, the ideal advocate, the man of honor, the accomplished gentleman.

He was a bold man, strong in the consciousness of rectitude, and not for all the world could give, the smiles of friends, the pleasures of power, did he ever for an instant hesitate to obey the dictates of his conscience, regardless of the penalties to be paid for his independence. "He was faithful to his convictions of truth when such fidelity cost dear."

It would not be proper that I should consume so much of the time of our Society as would be really requisite to delineate Mr. McCall's life, and I must close with this imperfect sketch of the main features of his career. But I leave it with the less regret, knowing that to the accomplished hand of Isaac Hazlehurst, the life-long friend of Mr. McCall, has been entrusted by the Law Association, the duty of preparing a memorial address, and I am sure that his eloquent pen will do justice to departed worth; that he will not fail to suitably commemorate

"That best portion of a good man's life,
"His little, nameless, unremembered acts
"Of kindness and of love."

---

*November 29th, 1832. Annual discourse before the Historical Society of Pennsylvania.

January 4th, 1836. Oration before the Zelosophic Society of the University of Pennsylvania.

September 5th, 1838. A discourse before the Law Academy of Philadelphia.

† Bar meeting held on November 4, 1880.

Note on the Protection of Oil Tanks from Lightning Stroke. By B. Howard Rand, M.D.

(Read before the American Philosophical Society, January 7, 1881.)

The frequency of the ignitions of the contents of tanks used for storing mineral oil, with the concomitant destruction of property and life has attracted much attention. The suggestions as to the means of prevention have been crude.

It is my purpose to offer a theory as to the cause, and a means of avoiding the mischief.

An air-tight tank of metal, or one sheathed with metal, would, if filled with crude rock-oil, or even with loose gunpowder, be safe from damage from lightning stroke. It would be no more in danger of the thunderbolt than a log-cabin similarly situated. If struck it would escape unharmed. The late Professor Clerk Maxwell suggested the protection of powder-magazines by sheathing them with metal. Professor Tait recommends the investigator of the so-called ball or globe-lightning to wear a suit of light copper armor. It would be safer to add a thorough ground connection. This could be made in most cases to the pipes.

As the level of the oil in the tanks must vary with the rate of the inflow and outflow through the pipes, openings are necessary to allow the egress or ingress of air. There may be occasion to lift the lid at times.

From the necessary openings and leaks around the lids, the light hydrocarbon vapours escape. These mingling with the air form an explosive mixture like the fire-damp of mines, which, if ignited at a distance of even hundreds of feet, will travel back and set fire to the contents of the tank.

To prevent this I suggest that the necessary vent-holes be protected with safety tubes after the plan of Hemming's, or with several layers of fine wire gauze, strong enough to resist any probable breaking by mechanical shock. These should be protected from dust and wet by loosely fitting covers.

On the approach of a thunder-storm, the outflow should be checked, so as to avoid an indraught, which we so well know will render useless in many cases the protecting metallic mesh.

Where moveable covers are used, they should have the ordinary seal used in telescopic gas-holders. Glycerine in the seal is recommended as it does not evaporate and is not affected by changes of temperature within the limits of ordinary atmospheric fluctuations.

Where it is necessary to introduce chemical agents in the process of refining, the well known safety traps should be used.

Stated Meeting, January 21, 1881.

Present, 12 members.

Vice-President, Mr. ELI K. PRICE, in the Chair.

A letter of envoy was received from the Central Observatory, St. Petersburg.

A letter of acknowledgment was received from Prof. L. Rutimeyer, Basel, dated Jan. 1, 1881 (104, 105).

A circular was received from the Census Bureau.

Donations for the Library were received from the Statistical Bureau at Stockholm; the Geographical Societies of St. Petersburg, Paris and Bordeaux; Herr E. Reyer, of Wien; Zoologischer Anzeiger, Leipsig; Revue Politique, Paris; Academia dei Lincei, Rome; Revista Euskara, Pamplona; Nature, Journal of Forestry, and Chemists' Journal, London; Mr. Thos. Henry Thomas, Cardiff, Wales; Canadian Naturalist, Montreal; Boston Society of Natural History; Franklin Institute, Medical News, Journal of the Medical Sciences, Journal of Pharmacy, Mr. Henry Phillips, Jr. and Mr. Franklin B. Gowen, Philadelphia; Wyoming Historical and Geological Society, Wilkes-Barre; Commissioner of Education, and Department of Engineers, Washington; California Academy of Sciences, San Francisco; Sociéta de Geographica y Estadistica, Revista Cientifica, and Ministerio de Fomento, Mexico.

The death of the Rev. Humphrey Lloyd, D.D., of Dublin, Jan. 17, 1881, aged 80, was announced by the Secretary.

A geological reconnaisance of parts of Lee, Wise, Scott and Washington counties, Va. by J. J. Stevenson, with six small cuts, and the colored map (mentioned at the last meeting) was presented.

Mr. Lesley was elected Librarian for the ensuing year.

The following members were placed upon the Standing Committees:

Finance.	*Hall.*
E. K. Price,	S. W. Roberts,
B. V. Marsh,	J. S. Price,
Henry Winsor.	W. A. Ingham.

Publication.	*Library.*
J. L. LeConte,	E. K. Price,
D. G. Brinton,	C. P. Krauth,
E. Thomson,	R. S. Kenderdine,
C. M. Cresson,	E. J. Houston,
G. H. Horn.	H. Phillips, Jr.

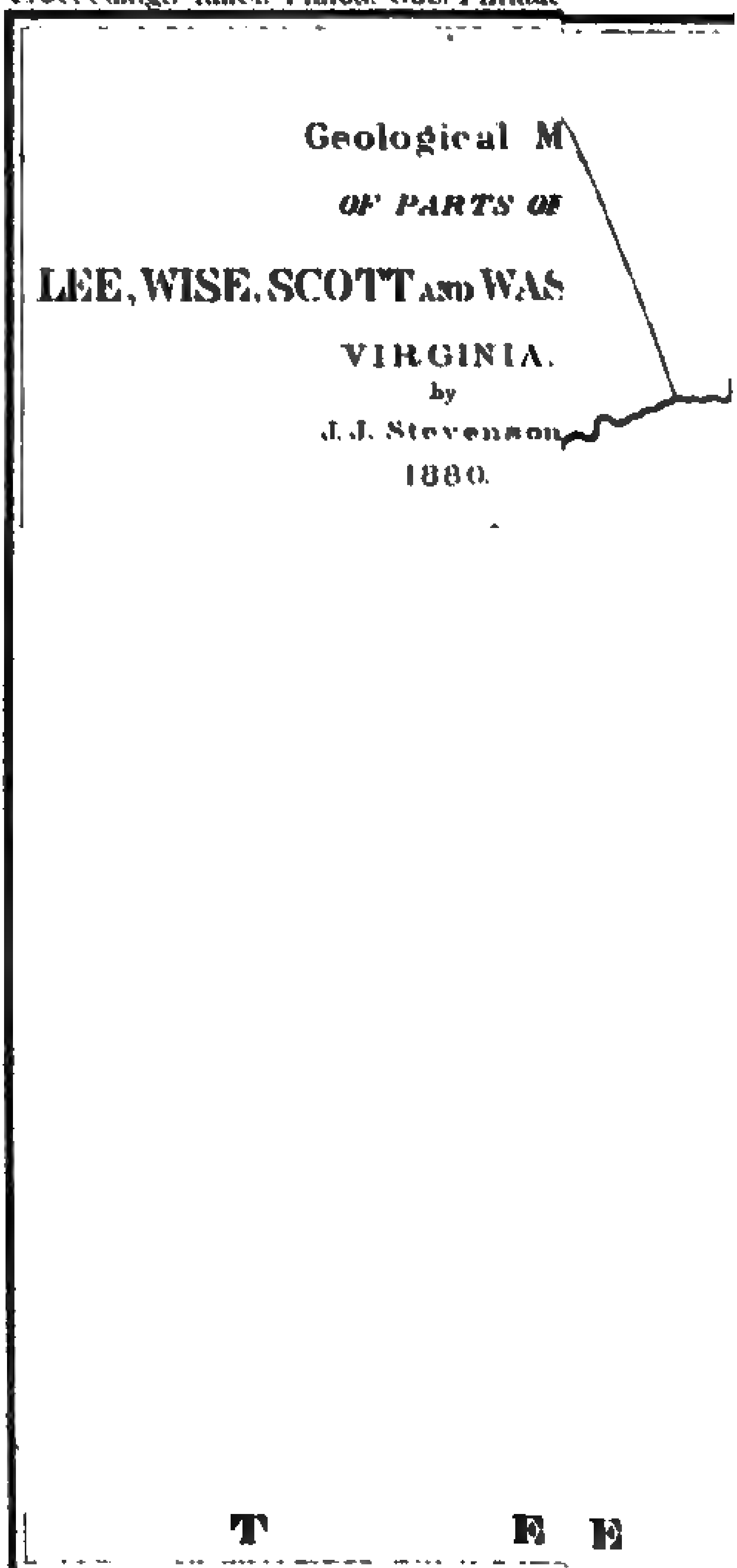
The annual reading of the list of surviving members was postponed.

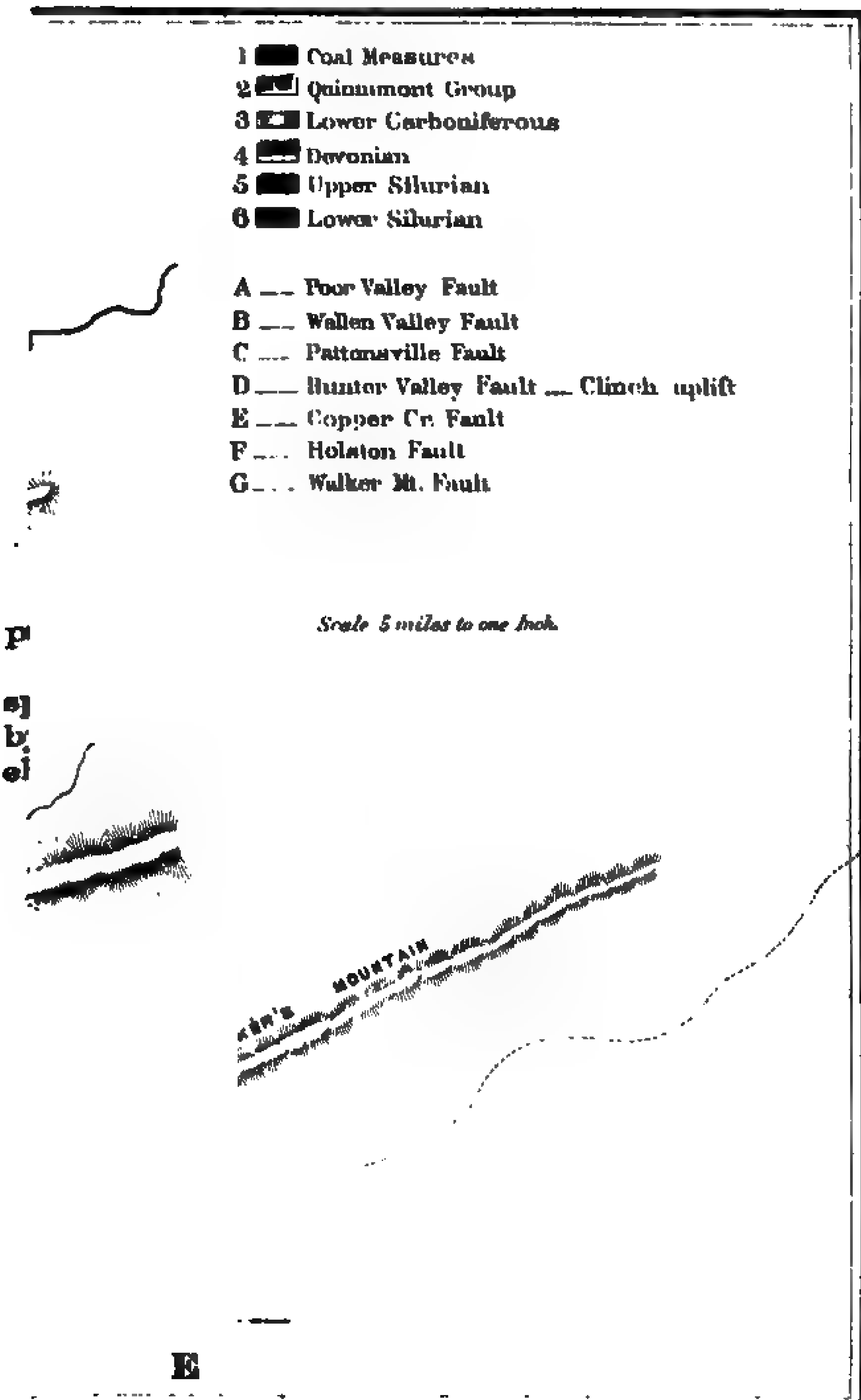
Pending nominations Nos. 909; 920 to 926 were read, spoken to and ballotted for; on scrutiny of the ballot boxes by the presiding officer the following were declared duly elected members of the Society:

Lewis S. Ware, of Philadelphia.
Joseph Lovering, of Cambridge, Mass.
Charles G. Ames, of Philadelphia.
Edward Y. McCauley, U. S. N.
Addison May, of West Chester, Pa.
Joseph J. Lewis, of West Chester, Pa.
Henry Carvill Lewis, of Germantown, Pa.
Dr. Charles Stewart Wurts, of Philadelphia.

And the meeting was adjourned.

Proceedings Amer. Philos. Soc. Philade




1 Coal Measures
2 Quinnimont Group
3 Lower Carboniferous
4 Devonian
5 Upper Silurian
6 Lower Silurian
A — Poor Valley Fault
B — Wallen Valley Fault
C — Pattonsville Fault
D — Hunter Valley Fault — Clinch uplift
E — Copper Cr. Fault
F — Holston Fault
G — Walker Mt. Fault
Scale 5 miles to one Inch.
MOUNTAIN
E

A Geological Reconnaissance of Parts of Lee, Wise, Scott and Washington Counties, Virginia. By John J. Stevenson, Professor of Geology in the University of the City of New York. (With six wood cuts and a colored map.)

(Read before the American Philosophical Society, January 21, 1881.)

Introduction.
I. *General structure of the area; description of the faults.*
II. *General description of the several groups.*
III. *Geology of the area drained by Powell river.*
IV. *Geology of the area drained by Clinch river.*
V. *Geology of the area drained by Holston river.*

In a former memoir,* the writer described a small part of Lee and Wise counties, and gave some casual observations respecting a part of Scott county. Examination of a larger area has shown that two serious errors, due to too ready acceptance of information respecting localities not visited, occur in that memoir, and has led also to a change in opinion respecting the structure of Stone mountain.

The counties examined occupy the extreme south-west corner of Virginia; Lee being in the angle between Kentucky and Tennessee, with Wise adjoining it along the Kentucky line, while Scott and Washington lie next along the Tennessee border.

The surface is broken by rudely parallel mountain ranges, separated by narrow valleys. The distance along the shortest line from the city of Bristol to the Kentucky border is barely fifty miles, yet in following that line one must cross Walker, Brushy and Clinch mountains; Moccasin, Copper and Buckner's ridges, Powell mountain, Wallen's and Poor Valley ridges, Stone and Black mountains. Several of these ridges are single, and have abrupt slopes, while others are compound, and their slopes afford grades not too difficult for wagons.

The area between the Great Valley of Virginia and Moccasin ridge is drained by the Holston river; that between Moccasin ridge and Powell mountain, by Clinch river; and that beyond Powell mountain to the Kentucky line, by Powell river. The Clinch and Holston unite to form the Tennessee river, and Powell river enters the former at not far from Knoxville. Of these rivers, the Powell rises within the area examined; the others have their sources far beyond toward the north-east.

A narrow strip of this region along the Kentucky border has been examined by Mr. P. N. Moore, of the Kentucky Geological Survey, and a summary account of his observations is given in the reports of that Survey, Vol. IV. Prof. Lesley's work, as described in his memoir,† is slightly overlapped by the writer's examination. The whole region was examined during the survey under Prof. W. B. Rogers. One is compelled to regret

* Read before this Society, August 20, 1880.
† Proceedings of this Society, 1872.

that the reports of that survey are so rare; since the map prepared by Prof. Rogers and published in "The Resources of Virginia," shows that the structure was admirably worked out. The faults are clearly shown on that map, and the distinction between the limestones of the Lower Carboniferous and the Lower Silurian was determined accurately, though at that time there was little aside from physical characters to depend on for identification. When it is remembered that the region was even more thinly settled forty years ago than it is now, one may not refrain from acknowledging the skill and patience with which the structure was worked out at that early day.

To obtain the material given in this memoir, one section was followed from Black mountain almost directly to Bristol; a second from Pennington's gap in Stone mountain to the Tennessee line by way of Estillville and Moccasin gap through Clinch mountains; shorter sections were followed across Moccasin and Copper ridges; while several of the faults were followed for from ten to twenty miles. Necessarily, many interesting details were neglected, and some points of importance were left undecided, as the object of the reconnaissance was purely economic.

No map worthy of the name exists, and that accompanying this memoir is based on the old State map, made in 1835. Some gross topographical errors have been corrected partially; others remain, which interfere seriously with a proper presentation of the geology; but to correct these would involve a complete reconstruction of the whole.

I. General Structure of the Area.

The structure is monoclinal, and the prevailing dip is toward the southeast. The one exception is in the area between Black mountain and the summit of Powell mountain, where, as will be shown, a cracked anticlinal exists. In passing from Black mountain to the Valley of Virginia at Bristol, one crosses

1. *The fault of Poor Valley ridge.*
2. *The Wallen valley fault.*
3. *The Pattonsville fault.*
4. *The Hunter valley fault, or Clinch river uplift of Lesley.*
5. *The fault of Copper creek.*
6. *The fault of the North Fork of Holston.*
7. *The fault of Walker mountain.*

Black mountain is a rude mass, which owes its origin solely to erosion. It is the dividing ridge between the waters of the Cumberland and those of Powell and Clinch rivers. Its course is irregular but bears westward and southward until, at a little way west from Pennington's gap in Stone mountain, it unites with the latter ridge. The only rocks exposed in this mountain are those of the Coal Measures, and their dip is northward, or north north-west. Toward Stone mountain, the dip suddenly increases until in that ridge it becomes almost, and at some places, wholly vertical.

Stone mountain is a bold narrow ridge with a N. 67° E. course, which

begins not far beyond the Little Stone gap and continues thence into Tennessee. It was examined from Little Stone gap to nearly three miles beyond Pennington's gap, a distance of nearly thirty miles, in which it has but two water gaps, those of Powell river and its North Fork, or, as they are commonly known, Big Stone and Pennington's gaps. A wind gap, the Little Stone, affords passage for the turnpike leading from Jonesville to Gladesville.

In his former memoir, the writer regarded Stone mountain as a fault, but he is now convinced from the conditions observed at Pennington's gap, that the mountain is but the side of an exceedingly abrupt fold, as will be explained in another paragraph.

In the Poor Valley, which follows the southerly foot of Stone mountain, the Devonian shales are shown underlying the Lower Carboniferous. At the head of the valley, the Lower Carboniferous is well shown in the divide between the South Fork of Powell river and the waters of Stony creek, where it is in direct contact with the Lower Carboniferous of Stone mountain. In the divide, it dips gently toward the south-east, while in Stone mountain the dip is almost vertical, the incline being toward the north-west or north north-west. The dips in the mountain become sharper toward the west, being 70 degrees in Big Stone gap, and 90 degrees in Pennington's gap. The rocks shown in the mountain gaps are the Lower Carboniferous, the Quinnimont group and the lower beds of the Coal Measures.

The fault of Poor Valley ridge must be described before the structure of Stone mountain can be fully explained. This fault is very nearly parallel to Stone mountain, though the increasing strength of the thrust, by turning the rocks directly on edge, has diminished the interval materially in the vicinity of Pennington's gap. The distance between the two ridges varies from a mile to a mile and a half. At its eastern extremity, the fault begins in a gentle anticlinal nearly opposite Little Stone gap. A crack develops in this anticlinal near the gap, by which the South Fork of Powell river crosses it, and increases rapidly in importance westward. The Devonian shales cross the anticlinal at its origin, while in the divide at the head of the valley, the Lower Carboniferous and part also of the Quinnimont group pass over it so as to be continuous with the rocks of Stone mountain. But the anticlinal soon becomes bold, and the fault develops, so that the ridge is divided below the mouth of South Fork of Powell into Poor Valley ridge and Wallen's ridge. There the extent of the fault is shown, for the Clinton is in direct contact with the middle shales of the Knox group. Poor Valley ridge continues westward to beyond the Tennessee line, and varies much in height and width. It is composed chiefly of Clinton rocks, while the Lower Helderberg, Oriskany and Hamilton occur in the narrow valley between it and Stone mountain.

The writer has stated in another paper that Stone mountain is a fault, and that it is the continuation of the *Clinch river uplift* described by Prof. Lesley. Mr. Moore, in the report of his reconnaissance along the border

of Kentucky and Virginia, maintains that Stone mountain is not a fault, but that it is a sharp fold and a typical example of the Cumberland mountain structure. The exposures beyond Little Stone gap and at Pennington's gap show this to be true. It is precisely like the structure of Brush mountain, Kentucky, of which an illustration is given in a long cross-section accompanying another of Mr. Moore's reports. At Pennington's gap the succession of Upper Silurian, Devonian and Lower Carboniferous is clear, and all the groups are conformable. Figures 1, 2 and 3 exhibit the structure of the whole fold; No. 1 being a cross section from the northerly slope of Stone mountain to Powell mountain; No. 2, a similar section through Big Stone gap, and No. 3, the section from Pennington's gap to Wallen's ridge.

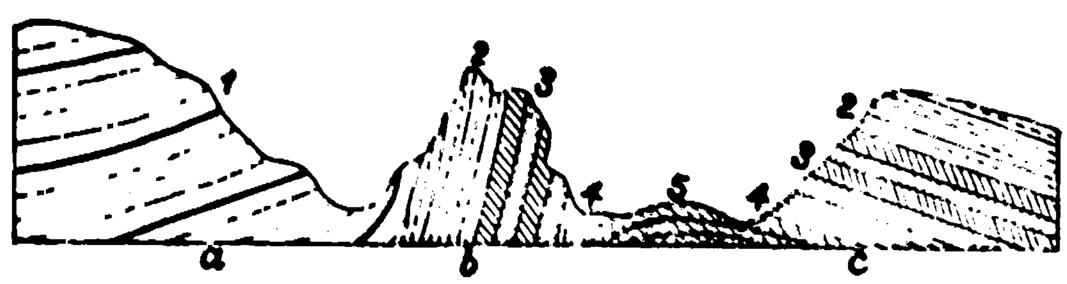


FIG 1.—Section from Stone mountain at Little Stone gap to Powell mountain. *a*, Slope of Black mountain; *b*, Stone mountain; *c*, Powell mountain; 1, Coal Measures; 2, Quinnimont group; 3, Lower Carboniferous; 4, Devonian; 5, Upper Silurian; 6, Lower Silurian.

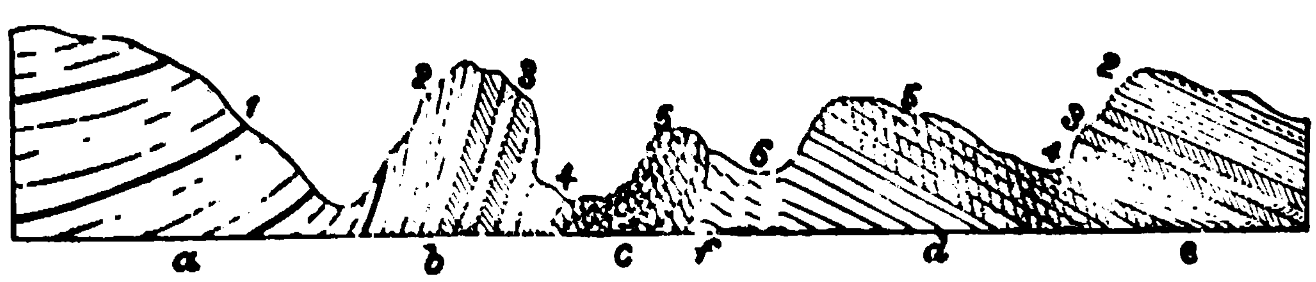


FIG. 2.—Section from Stone mountain at Big Stone gap to Powell mountain. *a*, Slope of Black mountain; *b*, Stone mountain; *c*, Poor Valley ridge; *d*, Wallen's ridge; *e*, Powell mountain; *f*, fault of Poor Valley ridge. Numbers as in preceding figure.

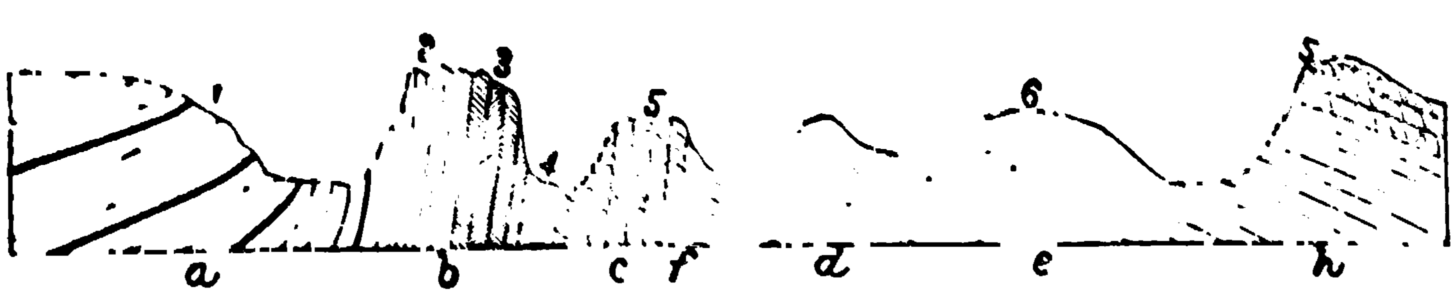


FIG. 3.—Section from Stone mountain at Pennington's gap to Wallen's ridge. *a*, Slope of Black mountain; *b*, Stone mountain; *c*, Poor Valley ridge; *d*, Chestnut ridge; *e*, Elk Knob; *h*, Wallen's ridge; *f*, fault of Poor Valley ridge. Numbers as in preceding figures.

The change of structure beyond the fault of Poor Valley ridge will be explained in its own place.

Wallen's ridge includes the eastern extremity of Poor Valley ridge, and the two ridges become separate only beyond the mouth of South Fork of Powell river. Lower Silurian rocks are shown on its northerly side, Medina sandstone forms the crest, while Lower Helderberg and Oriskany are shown on the southerly slope. The structure, where the ridge first separates itself from Poor Valley ridge, is shown in Fig. 2, which represents the cross-section from Poor Valley ridge fault across Turkey Cove,

and the mountain to Powell mountain. There the ridge is narrow; but at some miles further west the conditions are as in Fig. 3, which shows the section from the Poor Valley fault on North Fork of Powell to the Wallen Valley fault near Stickleyville. Here instead of the single ridge seen at the Turkey Cove there are three ridges, known as Chestnut ridge, Elk Knob and Wallen's ridge. The folds in Chestnut ridge are exceedingly complex, and are well shown in the gap by which the North Fork of Powell river passes through it. The beds are folded without crushing, though some of the angles are as sharp and close as the bent elbow. But in Elk Knob the strata are practically horizontal until near the southerly slope where the dip becomes nearly 15 degrees. The rate increases toward Wallen's ridge as well as in the ridge, until, along the summit line, the Medina dips at nearly 40 degrees. The Upper Silurian rocks are reached on the southerly slope of the ridge.

The relations of Wallen's ridge to Powell mountain are somewhat complicated by the Wallen Valley fault, which begins at the head of Wallen's valley. As far as could be ascertained, no traces of that fault exist further east. That part of Powell mountain which lies east from Slemp's gap, through which the North Fork of Clinch flows, has a very different structure from that of the part lying west from that gap. The eastern division is but a continuation of Wallen's ridge, the separation being due solely to erosion; for, on the bold bluff which Powell mountain presents to the valleys of the South Fork of Powell river and the North Fork of Clinch river, the section is but a continuation of that shown on the slope of Wallen ridge; and the Lower Helderberg, Oriskany, Hamilton, Lower Carboniferous and Quinnimont group appear in regular succession, while the Quinnimont group covers the southerly slope of the mountain to where it is cut off by the Hunter Valley fault. The conditions observed on this side of Powell mountain will be described in connection with that fault.

The Wallen Valley fault begins at the head of that valley, and continues into Tennessee. It passes along the southerly side of Wallen's ridge, and is crossed by the Jonesville and Estillville road at, say, nearly half a mile from Wallen's creek. On its northerly side are the Lower Helderberg rocks, ill-exposed where examined, dipping almost south-east at 45 degrees, while the limestones of Formation III are shown on the southerly side dipping in the same direction at 30 degrees. The upper part of No. II is shown near the fault, but only a small part of that group is brought up where the examinations were made. It is not wholly certain that this fault begins within Wallen's valley, but no traces of it were seen on the other side of the mountain, where, however, the forest is dense, and exposures are few and not satisfactory. It is certainly absent from the valley of North Fork of Clinch at three miles further up. This fault is important economically, for, in great measure owing to its sudden development, Powell mountain west from Slemp's gap has been so far elevated that the Devonian, Lower Carboniferous and Quinnimont group, still present on the other division of the mountain, have been wholly removed by erosion.

Powell mountain west from Slemp's gap is but a repetition of Wallen's ridge as shown on the opposite side of Wallen valley. The limestones and shales of Formation III are exposed on its northerly side, Medina sandstone follows its crest, while the Lower Helderberg, Oriskany and a fragment of the Hamilton are shown on its southerly side. These rocks are suddenly cut off by the

Pattonsville fault, which is marked by a low ridge at, say, two-thirds of a mile from the crest of Powell mountain. No evidence of its presence was found beyond the railroad line, and, in all probability, it originates very near that line. The structure between the Wallen's valley fault and the Hunter Valley fault (Clinch uplift) is shown in Fig. 4. This fault

FIG. 4.—Cross-section through Powell mountain from the Wallen Valley fault to the Hunter Valley fault in Buckner's ridge. *a*, Powell mountain *b*, Pattonsville ridge; *c*, Buckner's ridge; *f*, Wallen's Valley fault; *f'*, Pattonsville fault; *f''*, Hunter Valley fault or Clinch uplift. Numbers as in Fig. 1.

brings up the Lower Helderberg rocks against the Hamilton shales; the former describe a shallow synclinal and low anticlinal, so that, before reaching the North Fork of Clinch river, the Hamilton shales are again exposed, dipping very sharply toward the south-east. The details of this fault cannot be expressed on the map, owing to the narrowness of the area affected by it. It is evidently parallel with the Wallen Valley fault, and it is responsible for the absence of the Lower Carboniferous rocks from the valley at the southerly foot of Powell mountain. This fault, according to Prof. Safford's map, does not exist in Tennessee.

The Hunter Valley fault is the same with the *Clinch river uplift*, which is so fully described by Prof. Lesley in his memoir on the geology of Wise and Tazewell counties.* As it lies at a considerable distance from Clinch river within the area under consideration, it is best to apply to it a local name. Its direction, as laid down on the map, does some violence to the truth, but the writer has preferred to give the direction of the fault properly, even though in so doing it is thrown somewhat out of its geographical relation. This fault enters Scott county near its north-western corner, whence it follows an almost straight line to the gap made through it by the North Fork of Clinch river, being crossed very near the head of Powder Mill gap by the Bristol railroad, and by the Jonesville and Estillville road at barely two miles from Pattonsville. It is crossed but once by the North Fork of Clinch.

This is probably the most violent of the faults observed within the region examined. The rocks on both sides of the fracture are bent upward, and, at more than one locality, the structure is distinctly that of a cracked anticlinal. The energy of the lift varied, for along a very considerable dis-

* Proceedings of this Society, 1872.

tance, the Hamilton shales are the lowest beds exposed on the northerly side of the fault, while at several localities lower groups, even down to the Medina, have been brought up.

At the gap of North Fork of Clinch, the Hamilton shales are well exposed on the northerly side at some distance from the line of break, where they are abnormally thick, show a strike N. 80° E. mag. and are dipping toward the fault at 40 degrees. Some sandstones seen between these and the foot of Buckner's ridge may represent the Lower Helderberg, and the Clinton rocks are exposed at the foot of the ridge. Whether or not the succession is complete, was not determined, as the side of the ridge is deeply covered with debris; but fragments of quartzite-like white sandstone were seen, which bear much resemblance to the Medina sandstone as shown in Moccasin gap of Clinch mountain. The exposures are all poor and the Clinton was recognized only by its fossil ore. The probable structure is doubtless as represented in Fig. 5.

FIG. 5.—Probable structure of Hunter Valley fault at North Fork gap. *f*, Hunter Valley fault. Numbers as in Fig. 1.

The fault is crossed by the Jonesville and Estillville road at two or three miles further east. There the Hamilton shales, shown in the river "bottom," appear to be in contact with the calcareous sandstones of the Knox group, which form a bold wall along the line of fault. These shales are dipping toward the fault, but they may be folded as they are near the North Fork gap. At four or five miles further east, one has passed beyond the influence of the Pattonsville and Wallen Valley faults, and has reached the southerly foot of Powell mountain in Hunter valley. Standing here at the railroad line, he can follow with his eye, the course of the fault in each direction, for it is marked by the low and sharply serrate ridge known as Buckner's ridge. This seems to follow an almost straight line from the county line to the North Fork gap.

In the Hunter valley, the wall of Knox sandstone is as well marked as it is along the North Fork of Clinch, while on the other side the Quinnimont group covers the slope of Powell mountain and extends into the valley. Near the end of the valley, the North Gap structure is repeated, but only the Lower Carboniferous and the Devonian are turned up. Beyond this, no exposures exhibiting the structure were seen until Stony creek was approached. The sandstone wall is distinct all the way, but the debris from the conglomerates covers the whole "bottom" deeply even to the foot of the wall. Toward Stony creek, the structure becomes very similar to that observed in the North Fork gap, but time did not admit of working out its details. The Lower Carboniferous, the Devonian and the Silurian as far down as the Clinton at least, were recognized on Stony creek between the last exposure of the Quinnimont series and the wall of Knox sandstone.

The general structure, then, must be as represented in Fig. 6, which shows also the structure of Powell mountain. The Quinnimont series caps the

FIG. 6.—Cross-section along Stony creek through Powell mountain and Buckner's ridge. *a*, Powell mountain; *b*, Buckner's ridge. Numbers as in Fig. 1.

bluff overlooking the valley of South Fork of Powell river. Thence for several miles the dip is gentle, but within somewhat more than a mile from the fault it suddenly increases. becoming rather more than 30 degrees, and at the last exposure of the rock it is nearly 45 degrees. This change in rate is so abrupt that where the narrow valley follows the line of change, a fracture at once suggests itself as the only explanation of the condition.

It is altogether probable that a close, sharp fold exists within two or three miles south-east from the Hunter Valley fault. The shales alongside of Clinch river above the mouth of Stony creek are violently twisted and the plications are as close as those frequently seen in Archæan schists. The shales themselves in many places are jointed and have an indistinct slaty cleavage; but they show no other signs of metamorphism. The rock forming the bluff on the opposite side of the river is a pyritous sandy limestone very like that which is at the base of the Knox group. A similar condition was observed in crossing Buckner's ridge along the Jonesville and Estillville road, at probably fourteen miles west from Stony creek.

Copper ridge lies on the southerly side of Clinch river, until within six miles of the Tennessee line, where it is crossed by that river. It is a monoclinal, but the dip is irregular, as is shown along the Stony creek road as well as along the road leading from Gray's ford on Clinch river to Nickelsville on the southerly slope of the ridge. The dip at Clinch river is not far from 40 degrees; at two miles from the river, the beds are almost horizontal; but toward the southerly side of the ridge, the dip increases to almost 33 degrees. The only rocks exposed in this ridge belong to the Lower Silurian groups. Prof. Lesley, on the map accompanying his memoir on Wise and Tazewell counties, colors Clinton along the southerly side of this ridge; but no Clinton is present within Scott county.* The structure of the ridge in this county suggests the possibility that, at no great distance eastward, the ridge may consist of a double anticlinal with a shallow synclinal along the crest, in which some Upper Silurian rocks may be held.

The Copper Creek Fault, as appears from Prof. Lesley's map, extends for a considerable distance into Russell county, which adjoins Scott on the north-east. It was examined by the writer very near the Russell county

* Prof. Lesley did not visit this portion of Scott county.

around the headwaters of the South Fork of Powell river and its tributary, Wildcat creek. This embraces so much of the region between Stone mountain and Powell mountain as is drained by those streams.

At the apex of this space, where Stone and Powell mountains come together, just east from Little Stone gap, one finds in the valley only the Hamilton shales. The gentle anticlinal, in which the fault of Poor Valley ridge originates, soon brings up the Oriskany, the Lower Helderberg, and, at a little way further west, the Clinton ore group. The ridge formed by the anticlinal and gradually developing fault is known here as Wallen's ridge and shows the Clinton group on both sides, with the higher groups at a little distance from the foot. No detailed section was made on Powell mountain, but the Hamilton shales are at its base; higher up is the Lower Carboniferous, forming a conspicuous band along the face of the mountain; while above it the Quinnimont group extends to the crest, whence it may be followed to the Hunter valley.

Along Wildcat valley and the southerly slope of Wallen's ridge, Upper Silurian rocks prevail, the Medina at the crest of the ridge, the Clinton lower down the slope, while the Lower Helderberg occupies the valley and here and there reaches some way up the side of the ridge. The Clinton ores are unusually good here, that from one bed showing 53.6 per cent. of iron with but 0.116 per cent. of phosphorus.* The Lower Helderberg shows two ore-horizons, of which the upper may belong in part to the Oriskany. The lower horizon has an unusually good brown hematite, with 52.55 per cent. of iron and only 0.051 per cent. of phosphorus. The pockets of good ore are separated by stretches of varying length, in which an enormous amount of brown hematite is seen, but so mixed with sand as to be altogether unavailable. Beyond all doubt the higher horizon carries much good ore, but the old workings, whence ore was obtained for a Catalan forge, have been filled up and only the silicious ore is exposed.

The Helderberg ores of Poor valley are of uncertain value. Some fair ore occurs at several miles east from Big Stone gap, but the most of that seen there is silicious and evidently belongs to the higher horizon. It contains many fossils characteristic of the Lower Helderberg. Further west, the ore seems to be wanting, no evidence of its presence having been observed at any exposure between Big Stone and Pennington's gap.

The best exposure of the Hamilton shales in the Poor valley is at a mile or so east from the Big Stone gap, where the rock seems to be thicker than it is further west. It is said to yield fossils there. The increasing strength of the disturbance westward makes the dip of these beds vertical before reaching Pennington's gap and exposures in that vicinity are not wholly satisfactory. The valley itself is very narrow until beyond that gap, where it opens up somewhat. No trace of Chemung rocks were found in the valley and the Lower Carboniferous rests directly on the lower black shales of the Hamilton.

*All analyses in this memoir, unless otherwise stated, are by Mr. A. S. McCreath, chemist to the Second Geological Survey of Pennsylvania.

No good section of the Clinton was obtained; the partial one obtained near Big Stone gap and given in the previous memoir contains all the details yet secured. The ores of this group are easily followed along the valley and ridge. Three beds occur not far from Big Stone gap, but only one of them is really important. This, as exposed on the Horton property at say a mile and a half from the gap, shows:

Hard ore	4′ 8″
Soft ore	2′ 6″

The lower part of the upper layer for, say 20 inches, is a very fair ore, though inferior to that from the lower portion of the bed. This is the middle bed. The upper bed is shown in the bank of Powell river not far from the gap, where it is from 5 to 8 inches thick; while the lower bed, as shown in Cedar gap, through Poor Valley ridge, contains little soft ore. The same beds are shown in the gap of Powell river through Poor Valley ridge and some of the ore from that locality has been reduced in Mr. Pennington's forge, where it proved good. Mr. Pennington has opened three beds of ore near his gap, but of these only the middle one is good. This shows:

Soft ore	4″
Clay	8″
Soft ore	25″

The clay is irregular and is said to disappear, so that the ore is sometimes fully 3 feet thick. The upper layer at this exposure is pebbly and the lower layer is equally so for an inch or two at the top; but Mr. Pennington states that this is an abnormal condition and that the pebbles are rarely present. This ore is mined to supply Pennington's forge at which about 200 pounds of excellent iron are made daily.

Powell Valley.

Throughout this valley, which embraces the whole space between Poor Valley ridge and Wallen's ridge, one finds only formations II and III. The distinction between the groups was not made out in detail, for the structure is too involved to be worked in a reconnaissance. It is altogether probable that the magnesian beds of the Knox group occupy the northern side of the valley in the wider parts of the area. They lie close to the fault in the Turkey cove, while, nearer Wallen's ridge, the beds of the higher group are well shown and yield great numbers of characteristic fossils. Good localities for collectors were seen along the road crossing Wallen's ridge from Turkey cove, and along the Jonesville and Gladesville road in the cove. The magnesian limestones on Elk Knob are practically horizontal and weather into detached blocks and pillars, making the long summit of that hill a "rock city." Brown hematite of excellent quality is said to exist on Chestnut ridge in this valley; and some of it has been tried with good results at Pennington's forge.

Wallen's Ridge and Valley.

At Turkey cove, the limestones of III rise high up on the side of Wallen's ridge, but the shales belonging at the top of the group are concealed along the road crossing the ridge. Further west, however, as the ridge is pushed away toward the south-east, the limestones reach only to its foot or to but a little way up its side. The shales are well shown along the Jonesville and Estillville road as it winds up the mountain. They are dark and fissile below but become somewhat sandy above. Thin irregular bands of limestone occur, all of which are fossiliferous. The thickness of the shales is not far from 700 feet.

The Medina sandstone is reached at the summit of the ridge, where, for the most part, it is fine grained and compact; but it contains some layers of shale and an occasional bed of conglomerate. Exposures are incomplete near the road, but the rock forms cliffs at two or three miles further east. The thickness, as estimated, is not far from 350 feet. The Clinton group is reached on the southerly side, where it is not well exposed. The fossil ores are shown at several places, but are best seen near the head of the valley, where Mr. Jerome Duft has explored them to a slight extent. The Lower Helderberg rocks are mostly concealed.

The Wallen Valley fault passes very near the southerly foot of Wallen's ridge, and is crossed by the Jonesville road at perhaps three-fourths of a mile from Wallen's creek. The exposures near the line of fault are very poor, but they suffice to show that the beds in contact with those of the Lower Helderberg belong near the top of the Knox group, for the soil has a deep red color and fragments of chert are scattered through it. The first satisfactory exposures are those of the Trenton and Nashville group, whose beds are well shown at Stickleyville and elsewhere along Wallen's creek. They are very fossiliferous, though the number of species found at Stickleyville is small. The following were seen:

Stromatopora; Chaetetes petropolitana; Bryozoans; Strophomena alternata; Leptaena sericea; Orthis testudinaria; Orthis occidentalis; Orthis tricenaria?. The *Chaetetes* is often replaced by chert, as is also the case on the northerly side of Elk Knob in Powell valley.

The limestones of this group continue nearly half way up Powell mountain, and, thence to the summit, the shales of the group are occasionally shown. The Medina sandstone is reached at the summit, where one looks down into the area drained by Clinch river.

As the Wallen valley fault disappears north-eastward, the outcroppings of Upper Silurian on the southerly slopes of Wallen's ridge and Powell mountain approach each other; and on the easterly face of the divide between Wallen's creek and the North Fork of Clinch, the two outcrops seem to have come together, as do the similar outcrops on Wallen's and Poor Valley ridges, where the fault of the latter dies out. No detailed examination of this divide was made, and the structure was ascertained only in so far as was possible in passing through Slemp's gap.

IV. Geology of the Area Drained by Clinch River.

The whole of this area lies within Scott county. For convenience of description, it may be regarded as divided by the road leading from Big Stone gap to the mouth of Stock creek. The easterly division extends from the crest of Powell mountain to that of Moccasin ridge, and is drained by several streams, to which reference will be made in their place; the other division extends westwardly to the Tennessee line and southwardly from the crest of Powell mountain to Clinch river. It is drained principally by Little Stock creek and the North Fork of Clinch river.

The Western Division.

The Medina sandstone is somewhat imperfectly exposed on the summit of Powell mountain along the Jonesville and Estillville road, but appears in cliffs at but a little way further east. Its junction with the shales of Formation III is well shown at the roadside, and is very sharp, there being no transition bed. The Medina, for 35 feet from the base, is massive, cross-bedded, and not at all conglomerate, though here and there a pebble appears. Impressions of *Arthrophycus*, though not abundant, are by no means rare. Some imperfect exposures of Clinton rocks were seen at about one-third of the way down the mountain slope and numerous fragments of fossiliferous ore lie scattered in the road and on the hillside. Only one bed, however, was found in place, and its ore is highly silicious. Further east along this slope of the mountain, three beds have been exposed on property lately belonging to the Kane estate, which are equivalent to the three beds seen in the Poor Valley ridge. The upper one is very thin, and its ore is silicious, but the middle and lower beds are of workable thickness and their ore is good, though evidently somewhat leaner than that from the middle bed of the Poor Valley ridge.

These ores extend along the mountain face quite to the head of the North Fork of Clinch river, whence they cross the divide and continue along the southerly face of Wallen's ridge along Wildcat valley; but no measurement of the group or of its ores was made in Slemp's gap or above it along the North Fork of Clinch.

Still further down the slope or very near the foot of the mountain are the Lower Helderberg and the Oriskany, beyond which come the shales of the Hamilton. A small tributary to the North Fork of Clinch flows along the foot of the mountain, and the road to Sneedville follows it. These rocks are exposed along this stream, and the shales are reached at Robinson's mill, where they are dipping almost southward at a high angle. At a little way below the mill, the stream enters a gap through a low ridge produced by the Pattonsville fault, and on the other side it joins the North Fork. At the entrance to the gap, one reaches the coarse sandstone, and the limestone at the base of the Lower Helderberg, both of which have been pushed to 5 degrees beyond perpendicular. Several exposures of Lower Helderberg rocks occur within this gap, but the section is not continuous.

On emerging from the gap made through this low ridge, the stream enters the North Fork, which there changes its course, and for a short distance flows irregularly along the strike. The road follows the right bank of the stream, and winds so as to be now in the Lower Helderberg, then in the Hamilton shales. The upper limestone of the Lower Helderberg is well exposed at the roadside, not far below the gap, where it underlies the Oriskany, which is ferriferous. The river changes its course near Mr. James Robinet's place, and breaks across the Hunter Valley fault (Clinch River uplift), whose course is marked by Buckner's ridge. The Hamilton shales are fairly well exposed here and are dark throughout. Those resting on the Oriskany are richly carbonaceous, and films of *coal* are common in one layer, which is nearly 18 inches thick.

No rocks newer than the Hamilton shales are shown between the crest of Powell mountain and Buckner's ridge, as far, at least, as two miles west from the North Fork gap in the latter ridge. If the Pattonsville fault were absent, there would be ample room for the Lower Carboniferous groups, which, indeed, are present on Powell mountain in the other division of this area. A material change in the character of this fault must take place at not far from the gap, for Prof. Safford's map shows that the Lower Carboniferous groups are present at the State line both on the slope of Powell mountain, and on the ridge marked by the Pattonsville fault.

The gap of North Fork of Clinch exhibits the complicated structure of the Hunter Valley fault or Clinch River uplift. The pyritous calcareous sandstones, belonging to the base of the Knox group, form a bold ridge with the rocks dipping southward at almost 50 degrees; but at the base of the cliff on the northerly side, a considerable mass of limestones, reddish and white sandstones was seen. This is not less than 150 feet thick. Behind it is an imperfectly exposed interval between the base of this bluff and the last exposure of Hamilton shale, in which are fragments of sandstone not unlike the Oriskany. This mass is covered with débris and the succession of its beds could not be made out. Unsuccessful search was made for fossils. A conglomerate of rounded quartz pebbles bound by red hematite occurs here, and bears much resemblance to the Clinton ore; with it is a ferruginous sandstone, which, when casually examined, appears to be an iron ore. It is, however, merely a very fine-grained ferruginous sandstone. This is shown on both sides of the gap, and the apparent amount of ore is very great. But the material is utterly worthless as appears from Mr. McCreath's analyses; No. 1 being the conglomerate, and No. 2 the ferruginous sandstone.

Metallic iron	12.050	11.550
Sulphur	0.052	——
Phosphorus	0.862	——
Insoluble residue	69.400	——

This was worked many years ago in a forge, whose ruins still remain in the gap.

Returning now to the Jonesville and Estillville road, one finds the Lower

Helderberg, Oriskany and Hamilton as at Robinson's mill on the Sneedville road, and the little village of Pattonsville stands on the Hamilton ; but the Pattonsville fault is crossed by that road immediately beyond the village and the Lower Helderberg is brought up as in the gap below Robinson's mill. The Oriskany sandstone is reached again near the "bottom" of North Fork of Clinch and varies in color from rusty yellow to dingy white. The rock is very friable and it must be somewhat calcareous, as the surface has given way at many places, showing the presence of caverns beneath. The hills are covered with loose reddish yellow sand, derived from this rock. Both the Lower Helderberg and the Oriskany sandstones are fossiliferous but the fossils are very obscure. Brown hematite occurs on the Pattonsville ridge and is continuous up the North Fork of Clinch. No analyses of this ore have been made, but the quality seems to be good. The Hamilton shales are continuous to the wall of Powell mountain in the other division of this area and are fairly well exposed at many places. Here, as at many other localities, they are supposed to hold *coal.*

Ascending the North Fork one reaches the strip of Lower Helderberg rocks in Slemp's gap near Ward's mill, and the upper limestone of that group is well shown at but a little way above the mill. These rocks remain in sight on both sides of the road until the summit between Clinch and Powell is reached. The Oriskany was not seen here, its place being concealed.

Returning again to the Jonesville and Estillville road, one crosses the Hunter Valley fault and enters Buckner's ridge at probably 2 miles from Pattonsville. An ill-exposed space of about 10 yards exists here, but there seems to be no reason to suppose that any rock lower than the Hamilton shale is brought to the surface. The Robinet "ores" are clearly absent.

In Buckner's ridge the calcareous sandstones and silicious limestones at the base of the Knox group have a dip of 45 degrees, which soon decreases to 30 degrees. With these are thin beds of shale, and the whole thickness is not far from 500 feet. Above this series are shales with irregular beds of impure limestone, in all about 1000 feet thick. These are followed by massive limestone, some of it dolomite, which extends beyond the divide and appears on the waters of Little Stock creek. The exposures are indistinct beyond this divide, until at some distance one comes to shales which bear close resemblance to those which rest on the calcareous sandstones. These shales are well shown along Little Stock creek, which flows between them and the massive magnesian limestones. The shales are badly twisted. The creek flows through a tunnel in the limestone, which is not far from 600 feet long, and from 10 to 15 feet high.

Few observations were made in Big ridge, the continuation of Copper ridge beyond Clinch river. The rocks are the same as those seen in Copper ridge and it is altogether probable that the reports respecting the occurrence of iron and manganese ores are true. One may not do more than to assert the mere occurrence of these ores, as nothing has been done to determine the extent of the deposits.

The Eastern Division.

The gradual disappearance eastward of the Pattonsville and Wallen Valley faults has permitted the retention of much newer rocks on the eastern than on the western part of Powell mountain; so that on the former the Quinnimont group and not the Medina sandstone forms the crest of the ridge.

Powell mountain has an abrupt slope on the north-westerly side, and the face toward Slemp's gap is so steep that it can be climbed only with great difficulty. The succession of the rocks on these bluffs is distinct, the Quinnimont group forming the rim, with the Lower Carboniferous, the Devonian and the higher beds of the Silurian in order below it. No detailed section was made here, but the Chemung, if present, must be extremely thin, and the probabilities are altogether in favor of the conclusion that it is wholly wanting.

The Hamilton shales are well shown on the road following the foot of Powell mountain and they contain carbonaceous bands in which thin streaks of *coal* occasionally occur. One of these was seen at barely half a mile below Ward's mill. The Lower Carboniferous rocks make a well-defined band, curving round the end of the ridge in Slemp's gap and continuing to immediately beyond Powder Mill gap, terminating where the Hunter Valley road leaves the line of railroad. The Mountain Limestone group is exposed near the school-house not far from the railroad, where it contains *Pentremites godonii*, *Zaphrentis*, *Productus semi-reticulatus*, and *Chonetes*. The Hamilton shale is shown between it and the calcareous sandstone of the Knox group, turned up by the Hunter Valley fault or Clinch River uplift. No traces of any lower rocks were observed between the limestone and the line of fault.

The rocks of the Knox group form a sharp, though low ridge, which is continuous into Russell county. The Hunter Valley road lies behind the ridge and soon rises upon the Quinnimont rocks, which seem to be in contact with the beds on the opposite side of the fault. This, probably, is not the case, but the coat of débris between the last definite exposures of the conglomerate and the base of the sandstone wall is so thick as to conceal everything.

Coal blossoms have been seen in all the hollows leading from the northern side of Hunter valley into Powell mountain. Some *coal* has been obtained along the Laurel Fork of Stock creek, at probably two-thirds of a mile from the valley, but the gorge is so close and rugged, that the coal can be brought down only by packing it on men's shoulders. In a bed which has been opened along the main stream at only a few yards from the road, the coal is decidedly good, being preferred to all others by blacksmiths; but the bed is badly distorted and crushed. It stands at an angle of 45 degrees and varies in thickness from 2 inches to 14 inches within a distance of two or three feet. The sharp dip prevails to nearly half a mile from the valley, where it changes suddenly and becomes not more than 5 or 6 degrees. At

say a mile from the road, Mr. Horton has opened a bed on Stock creek, where the exposure is:

Sandstone	20′
Shale	5′
Coal bed	2′ to 3′
Clay, seen	0′ 8″

The roof is very insecure, the shale being slickensided in nests, and a serious fall was seen at 80 feet from the mouth of the pit. The coal is regular, shows no signs of crushing such as those observed in the higher bed and is an excellent fuel for domestic use. It contains a good deal of pyrites and blacksmiths complain that they need much borax when using this coal. Not a little mining has been done here and some of the coal has been carried to Estillville, nearly 20 miles away.

The higher bed is evidently the same with that seen in Pennington's gap under the "Bee Rock." Its characteristics and those of the rock above and below it are the same with those observed in that gap. The lower bed is not shown in the gap and it must belong somewhere in the ill-exposed interval, No. 7 of that section, as bold cliffs of conglomerate were seen below it. The interval between the two beds cannot be determined without careful instrumental measurement.

The upper bed has been opened by Mr. H. Stone at about a mile further up Hunter valley. His pit has fallen in and the bed is concealed, but its features as described by Mr. Stone are similar to those observed at Mr. Bailey's pit. Coal blossoms occur at several places on Cove creek, a tributary to Clinch river flowing from the valley across the fault; but no attempt has been made to ascertain either the thickness or the quality of the coal. Mr. Pinckney Carter has opened two beds on Stony creek. The upper of these is in all probability the same with that opened by Mr. Bailey and Mr. Stone, and it is exposed on Stony creek at somewhat less than one-fourth of a mile above Mr. Carter's house. It resembles a pocket rather than a bed and dips at somewhat more than 30 degrees. The opening extends along the face of the cliff for about 35 feet; the *coal* is three feet thick at the thickest place but pinches out on each side to nothing. More than 10,000 bushels of coal are said to have been taken from this clumsy pit and packed down a rocky trail by the diggers. The *coal* is excellent for blacksmiths' use. Another bed, at probably 300 feet further up the stream calculating in the direction of the dip, is 2 feet thick. A third bed, also about 2 feet thick, which is shown at say one-fourth of a mile up the left hand fork of the creek, has but an insignificant dip. The several openings seen along this stream probably belong to this bed.

Clay iron-stone occurs in moderate quantity in the shaly beds of the Quinnimont group, but there is not enough to be of economical importance.

The peculiar structure of the Hunter Valley fault in the vicinity of Stony creek has been explained in another part of this memoir. The fault appears to be simple until within less than two miles of that creek, and the only

rock shown at the base of the Knox wall is some Hamilton shale. But at Mr. Boatwright's place on Stony creek, the Lower Carboniferous, Hamilton, Oriskany, Lower Helderberg and Clinton were all recognized between the Conglomerate and the Knox group. These seem to come in reversed order as already explained.

The exposure on Mr. Boatwright's property is good. Two beds of the Clinton ore were seen there, which represent the upper and middle beds of the Poor Valley ridge. The upper bed is silicious and no special investigation of it was made. The other was exposed to a thickness of 2 feet for examination and it is said to be 6 feet thick in an excavation now filled up. But this thickness is doubtless an exaggeration, and the excavation may have followed the dip, which is abrupt. *Leptocœlia hemispherica* was recognized in this bed. The ore analyzed by Mr. McCreath yielded:

Metallic iron	43.650
Sulphur	0.008
Phosphorus	0.101
Insoluble residue	31.480

The Lower Helderberg brown hematite is exposed at several localities here on both sides of Stony Creek valley. Samples of the ore analyzed by Mr. McCreath showed:

Metallic iron	41.875
Sulphur	0.060
Phosphorus	0.890
Insouble residue	22.200

But it is clear that the samples from this bed are not altogether fair, as the yield in a forge seems to have been greater than the amount of iron shown by analysis. This ore was digged to some extent for use at the forge on Moccasin creek near Estillville; but the diggings were abandoned many years ago and the samples were taken from loose pieces which had been weathering for probably 20 years. The limestone of the Lower Helderberg is very fossilliferous and its species ally it closely to the Delthyris Shaly Limestone of the New York group. The Oriskany sandstone is well shown and contains *Streptorhynchus hipparionyx.*

There is little of interest between the Hunter Valley fault and Clinch river. In descending Stock creek, one finds himself constantly in the shales and limestones of the Knox group and the dip is not rapid until near the river. The creek flows through a great tunnel in magnesian limestone. The limestone is so magnesian that the inhabitants of the neighborhood use it as a purgative instead of epsom salts. Midway in the cliff, which overhangs the mouth of the tunnel, is the entrance to a great cave which reaches to within 65 feet of the summit of the hill. The tunnel is 500 feet long, 25 feet high and 35 feet wide. The surveyed line of the Bristol Narrow Guage Railroad passes through it.

The elevated area known as Rye cove is but a little way east from Stock creek. There the dip of the limestones is gentle and the projecting rocks

interfere materially with agricultural operations. Between the mouth of Stony creek and Gray's ford, four miles further up Clinch river, the rocks show that they have described a fold. Along Stony creek, the calcareous sandstones at the base of the Knox group are shown succeeded by shales as near the North Fork of Clinch; above these are massive magnesian limestones containing much oxide of iron and covered with a red soil. But, as in so many other localities, the limestones are so poorly exposed that the structure cannot be made out. Near the river, the shales are shown again and are vertical, giving evidence of having been subjected to enormous pressure.

Copper ridge lies between Clinch river and Copper creek. It consists of three narrow ridges formed by the branches of streams, which flow longitudinally through it. The low divides occasionally render this subdivision obscure, but such obscurity is usually of short continuance. The rocks belong to the Knox and the Trenton and Nashville groups of Safford. The subdivision into ridges is mainly due to the thick cherty beds of the Knox group.

A pyritous calcareous sandstone, holding some limestones, is shown at the foot of the ridge along Clinch river. It bears close resemblance to the calcareous sandstone at the base of the Knox group, so close, indeed, that the writer at one time believed that it was the same and that its presence is due to a fault. But it is not succeeded by shales such as are shown near the Hunter Valley fault.

The dip is abrupt near Clinch river, but becomes gentler within the ridge, only to become abrupt once more toward the southerly side of the ridge.

The cherty rocks of the Knox group carry brown hematites and oxide of manganese, of which fragments occur plentifully along the crests of the minor ridges. Openings have been made at several places to supply ore to White's forge on Moccasin creek; but these have been abandoned for a long time and only fragments of the ore could be found. The manganese at some localities is decidedly good, as appears from Mr. McCreath's analysis of samples from the Salling property, which is as follows:

Metallic manganese	51.495
Metallic iron	0.567
Sulphur	0.000
Phosphorus	0.027
Insoluble residue	3.030

This ore contains 10.141 per cent. of baryta. The percentage of binoxide of manganese is 81.455.

V. Area Drained by the Holston River.

No examinations were made in this area west from the Estillville and Reedy creek road.

The rocks of Moccasin ridge belong wholly to the Knox and the Trenton and Nashville groups, but the higher beds of the latter group are reached only on the northerly side of Clinch mountain. Very good exposures of

that group and of the upper part of the Knox group can be obtained in passing from Clinch mountain through Estillville and thence towards Copper creek, by either the Rye Cove or the Stony Creek road. The higher beds of the following section were seen on the former road, while the lower beds were examined on the latter. There may be an error in No. 15, for that is the horizon at which the two sections were joined, and the thickness of that mass may be greater than is given. All thicknesses are based on estimates, the dip being such that instrumental measurement is necessary for accurate determinations:

Trenton and Nashville Group.

1.	Shale and thin limestone	600′
2.	Limestone and calcareous shale	25′
3.	Calcareous shale	180′
4.	Limestone	70′
5.	Shale	65′
6.	Limestone	45′
7.	Shale	50′
8.	Massive limestones	200′

Knox Group.

9.	Cherty rock and limestone	160′
10.	Limestone and shale	120′
11.	Concealed	60′
12.	Cherty rock	165′
13.	Light blue limestone	55′
14.	Concealed	15′
15.	Limestone, shale and chert beds	300′
16.	Variegated shale	70′
17.	Limestone	250′
18.	Shale	60′
19.	Limestone	260′
20.	Shale	80′
21.	Silicious limestone	200′

Total, Trenton and Nashville, 1185′; Knox group exposed, 1745′

No. 21 is exposed along Copper creek, and is the rock which, in this memoir, has been regarded as marking the base of the upper division of the Knox group. The dip throughout Moccasin ridge is not far from 30 degrees, but the rate increases on Clinch mountain, that at the base of No. 8 being 42 degrees.

No continuous exposure of the shales, No. 1, was seen; but, as far as observed here, the features are the same as on the northerly side of Wallen's ridge. Thin limestones were seen, several of which are fossiliferous. No. 2 is well shown on the side of Clinch mountain at the residence of Mr. R. A. Ayres, opposite the village of Estillville, where it consists of limestone, 2′; calcareous shale, 10′; ferruginous shale, 5′; limestone, 8′. The upper limestone is impure, irregularly bedded, and contains a few

fossils; the lower limestone is light gray, weathers blue, is richly fossiliferous, and contains some pyrites. No. 3 is shown at the same locality, and also along the road from Estillville to Moccasin gap. It consists of red and brown shales on Mr. Ayres' property, more or less calcareous, with some beds of limestone, which become more important at the exposures near Moccasin creek. No. 4, as exposed along the road to Mr. Ayres' house, is an almost continuous mass of limestone, much of it in thick beds, and some parts of it fossiliferous. Several of the thicker layers are streaked with white calcspar. The color varies from flesh-color to light gray, and there are parts which should take a high polish and be valuable as marble. But the greater part of the mass is somewhat argillaceous, and the weathered surface shows many flaws and distinct lamination. The unequal composition of some of the thick beds unfits them for ornamental use, and their unequal resistance to the weather unfits them for building purposes. This series is well shown along the foot of Clinch mountain for many miles.

No. 5 and 6 are much alike, the great difference being in the relative quantity of limestone and shale, limestone predominating in the lower and shale in the upper bed. The limestone is more or less nodular in both. This mass reaches to the "bottom" of Little Moccasin creek and is well exposed on Mr. Ayres' property. No. 7 is concealed in the immediate vicinity of Estillville, but a roadside exposure shows it to be filled with yellow shale.

No. 8 is an important mass, economically as well as stratigraphically. It includes the marbles of the series. The beds are all massive, from 10 to 20 feet thick, and are separated by thinner beds of shale. Many of them are finely granular, others have a conchoidal fracture; the colors are light gray, dark gray, reddish or flesh-colored, brown and nearly black. Some of the beds are streaked with white calcspar, others are fossiliferous, with the fossils replaced by calcspar, so that the rock is beautifully mottled. This effect is most striking in the reddish marbles, some of which are in no wise inferior to the Tennessee marbles used in the National Capitol. The beds are so thick that blocks of any desired size can be obtained. These marbles are well shown in the streets of Estillville as well as along the railroad line for several miles beyond that village. They are well exposed at many points along Moccasin creek between Estillville and the Russell county line. The limestone of No. 4 becomes more massive on Moccasin creek than it is nearer Estillville, so that, near the Russell county line, it might be mistaken for the marble. This series is shown in Copper ridge near Copper creek and in Big ridge, beyond Clinch river near Speer's ferry.

No. 9 is cherty. The bed immediately underlying the marbles is 12 feet thick and contains very little limestone. The rock directly under it is purer and has streaks of calcspar with lumps of chert; but the chert gradually increases downward until, at little more than midway, it predominates. With it are some beds of reddish sandstone. Toward the base, the limestone increases. This mass is well exposed on the Rye Cove road at barely half a mile from Estillville and its base is reached at a few yards above the

mill. It is the first ore horizon of the Knox group. The extensive deposit of brown hematite on Col. Shoemaker's property near Estillville evidently belongs here, as does also the fine deposit on the Big Branch of Moccasin creek at about 8 miles from Estillville. The quality of this ore is good, as appears from Mr. McCreath's analysis of samples from Col. Shoemaker's property, which is as follows:

Metallic iron	58.283
Sulphur	0.053
Phosphorus	0.075
Insoluble residue	8.840

Ore occurs at this same horizon on Copper ridge, having been opened on the McClennan property, near the Nickelsville road.

No. 10 is not fully exposed on the Rye Cove road and is better shown on the Stony Creek road. The limestone beds are from 5 to 15 feet thick and are separated by beds of shale from 10 to 20 feet thick. Very little chert was seen here. The interval, No. 11, is almost wholly concealed on the Rye Cove road and is but imperfectly exposed at other localities. On the former road, it is covered with red soil holding much jaspery rock and an excavation near its base has uncovered a thin silicious bed. At some imperfect exposures, seen elsewhere, it contains much white cherty rock. In all probability it is but a continuation of No. 12, which is very silicious and cherty in its upper part; but the limestone increases below, where chert is present only in irregular masses, which bear much resemblance to colonies of *Stromatopora*. Everywhere it shows more or less of oxide of iron and some of its cherty beds are honeycombed. Small pockets of black shale were seen in several places. This is the second ore horizon and many tons of brown hematite have been taken from it on Mr. Morrison's property near Estillville.

No. 15 is not shown in detail at any locality, but it is one of the most important members of the group, having been distinctly recognized at many localities along the summit of Moccasin ridge and along the middle and northern lines of summits in Copper ridge. For 50 or 60 feet, it is a silicious limestone, more or less ferruginous and cherty, which passes downward into a cherty rock resembling those already described and containing numerous thin beds of light gray sandstone. Below the middle a tight blue limestone occurs, which weathers dirty white, and is persistent, having been observed at many places on both Moccasin and Copper ridges. Toward the base the mass becomes more and more calcareous until it passes finally into a coarsely granular massive limestone. The cherty beds are the horizon at which some of the most important ore deposits occur, brown hematite having been obtained at Mr. Poston's, in Moccasin ridge near Estillville, as well as at several other localities along that ridge; while on Copper ridge, extensive digging has been done at four places and fine blossoms were seen at many others. Oxide of manganese occurs here at one locality on Moccasin ridge and at two on Copper ridge. The manganese underlies the iron.

The limestones of No. 17 are well shown only on the northerly side of Moccasin ridge along the Stony creek road as it descends to Copper creek. They vary from flaggy to massive, from silicious to very pure, and for the most part are gray. Balls of chert were seen in some of the beds. Nos. 19, 20 and 21, are practically one. The upper part is massive and a fairly good limestone; it contains some fossils but they are indistinct. Further down, the rock becomes flaggy or thinner bedded and the silica increases, until the whole is little more than calcareous sandstone. Pyrites begins near the bottom of No. 19 and increases to the bottom of No. 21. This rock bears remarkably close resemblance to that which lies at the base of the Knox group along the line of the Hunter Valley fault.

Clinch mountain is a bold rugged ridge, very narrow, and showing a sharply serrate crest. For nearly 50 miles it has but one water gap, and its slopes are so steep that no wagon road passes over it within Scott county, while trails for riding animals are few and difficult.

The Medina sandstone is reached at the summit of the mountain, and for a long distance forms the southerly slope, the newer rocks being found only near its foot. It is exposed imperfectly in Moccasin gap, but its composition is shown there better than at any other locality within Scott county. The succession as there observed is as follows:

1. Massive sandstone, much of it conglomerate, dark gray to almost milk white	75′
2. Massive sandstone, almost like quartzite, no grains shown on weathered specimens; weathered surface is rough and jagged; color on fresh surface, bluish white	150′
3. Concealed, but evidently containing some shale as well as some white sandstone	30′
4. Like No. 2 except that in some portions the surface of weathered specimens glistens, while the other always shows a dead white surface; weathered surface irregular	60′
Total	315′

In many respects, this rock bears much resemblance to the silicious beds of the Knox group; so much, indeed, that one would find difficulty sometimes in deciding the relations of a hand specimen.

Immediately above No. 1 of the section, there is in the gap a hard flinty rock belonging, in all probability, to the Lower Helderberg. It is irregularly bedded, loaded with oxide of iron, contains no fossils, and is not more than 15 or 20 feet thick. Above this come the Hamilton shales. The Clinton group and the Oriskany sandstone are evidently absent.

The Medina carries a brown hematite which has been examined at 3, 6, and 14 miles east from Moccasin gap. Samples taken from Mr. Ayres' property at 3 miles above the gap were analyzed by Mr. McCreath, with the following results:

Metallic iron	48.825
Sulphur	0.029
Phosphorus	0.926
Insoluble residue	19.910

Ore from another locality was mined for White's forge on Moccasin creek, and it is said by Mr. White to have proved even better than the ores from Moccasin ridge.

The Lower Helderberg is fairly well shown at little more than 2 miles east from Moccasin gap, where a fine grained sandstone, almost a true grit, rests on the Medina conglomorate. It contains many fossils, mostly indistinct, among which are *Spirifer* and *Platyceras*, nearly allied to Lower Helderberg forms. This rock shows no traces of iron ore, but immediately above it is a fossiliferous brown hematite, which has evidently replaced a limestone bed. The ore is bulky, and consists chiefly of casts of a *Favosites*, which is somewhat coarser than *Favosites helderbergiæ*, and resembles more a form occurring in the Coniferous. A cyathophylloid coral was obtained from the ore, but it has been misplaced. No other exposure was found.

The Hamilton shales are exposed at the mouth of Moccasin gap and thence to a considerable distance up the side of Brushy mountain. Above these are the Chemung sandstones, containing *Spirophyton* and *Spirifera disjuncta*, and forming the crest of Brushy ridge, the first ridge of Brushy mountain. The second ridge of that mountain is made up of Lower Carboniferous rocks, which continue along the Reedy creek road, to say a mile beyond the North Fork of Holston river. They describe a synclinal at the river. The abutments of the river bridge were constructed of rock from one of the higher limestones, which is composed almost wholly of *Fenestella*. The highest beds of the Lower Carboniferous are mostly bluish grits, with some impure limestones, and are well exposed along the road as it follows a little ravine beyond the Holston river.

The fault of North Fork of Holston is reached along this road at about a mile from the river or near the head of the narrow gap just referred to. This uplift brings the limestones and cherts of the Knox group again to the surface and these continue as the surface rocks to the Tennessee line. Their features are the same as on Moccasin ridge.

A "poor valley" between Clinch mountain and the first ridge of Brushy mountain, extends from the Tennessee line to far beyond the limits of this reconnaissance in Washington county. The Hamilton shales are exposed at many localities in it, but the succession of the group is obtained best by tying the partial section made in Moccasin gap to that made along the railroad grade between Mendota and the North Fork of Holston. The estimated thicknesses are as follows:

1. Dark sandy shale, fossiliferous, shown in the railroad excavations ... 130′
2. Yellow to ash colored shales, mostly well exposed in the railroad excavations, but the base seen only on the Abingdon road between Mendota and Moccasin gap; dip 45 to 50 degrees ... 550′

3. Dark fissile shale, with thin beds of sandstone, partial exposures between Mendota and Moccasin gap, but best shown in the gap........................ 150′

Total.................. .... 830′

The sandstone beds in No. 3 are fine grained, very white and prove to be an excellent firestone. These are shown in the Abingdon road at several localities between Mendota and Moccasin gap, as well as just below the mouth of the gap. Much of this material was used for lining at Bushong's furnace, 40 miles away in Tennessee, to which it was carried by wagon. The shales are very dark, and at many localities along the foot of Clinch mountain they are as badly wrinkled as mica schist, but they show no evidence of metamorphism Two thin beds of highly carbonaceous shale occur at the base of this group, which have been mistaken at several places for *coal*. They contain enough carbonaceous matter to burn and sometimes they yield a piece of fairly good *coal*.

The Chemung rocks are shown in all the ravines crossing the first ridge of Brushy mountain. An excellent exposure is afforded by the railroad excavation near the North Fork of Holston river, where the group is represented by shales and sandstone, mostly brownish gray and not far from 300 feet thick. A conglomerate layer, 4 to 6 inches thick, was seen very near the top and another of about the same thickness at 20 feet lower. Fossils were found immediately above the upper layer as well as at 10 feet below it; among these are *Spirifera disjuncta*, *Atrypa aspera* and a *Chonetes*. For the most part the specimens are badly preserved, as the layers in which they occur are ferruginous grits and the fossils are recognizable only on the weathered surface. *Spirifera disjuncta* and *Productella boydii* were found on fragments of sandstone belonging midway in the group, and a *Spirophyton* covers many layers near the base.

The Chemung is succeeded by the lower member of the silicious group of the Lower Carboniferous. The two groups are conformable, and the junction is well shown in the railroad cut.

A good section of the Lower Carboniferous was obtained between this point and the Holston fault by following the railroad line. It is as follows:

Mountain Limestone Group.

1.	Sandstones, limestones and shales.	800′
2.	Calcareous shales	60′
3.	Concealed	40′
4.	Calcareous shale	100′
5.	Limestone	105′
6.	Imperfectly exposed	250′
7.	Limestone	15′
8.	Shales	20′
9.	Limestone	50′
10.	Shale, imperfectly exposed	65′
11.	Limestone	15′

12.	Shale	80′
13.	Limestone	5′
14.	Shale	75′
15.	Limestone	20′
16.	Shale	150′
17.	Limestone	5′
18.	Shale	60′
19.	Limestone	80′
20.	Argillaceous limestone	60′
21	Granular to argillaceous limestone	100′
22.	Argillaceous limestone	35′
23.	Concealed	25′
24.	Granular limestone	30′
25.	Granular limestone	25′
	Silicious Group.	
26.	Cherty limestone	70′
27.	Granular limestone	35′
28.	Cherty massive limestone	65′
29.	Concealed	10′
30.	Limestone	30′
31.	Concealed	50′
32.	Limestone and shale	40′
33.	Massive limestone	125′
34.	Shales and thin limestones	90′
35.	Limestone	80′
36.	Calcareous shale	35′
37.	Limestone	25′
38.	Shales, sandstones and calcareous grits	100′

Total, Mountain Limestone group, 2270′ ; Silicious group, 755′

These thicknesses are all estimated, except those from No. 7 to No. 15. No. 1 was seen in the gorge of Wolf creek ; Nos. 2 to 20 inclusive were obtained along Abraham creek ; Nos. 21 to 30 inclusive are exposed in the river bluff below the railroad bridge ; and Nos. 31 to 38 are shown in the railroad excavations along the river bank.

No. 1 shows much the same features as in Pennington's gap, as well as along the road leading south-east from Moccasin gap. Its base is reached at the forks of Abraham's creek, at say one mile from the North Fork of Holston river. This mass forms the left hand wall of Wolf Creek gorge, through which the railroad passes for several miles. Here, doubtless, a detailed section could be obtained, but the wall is very steep and its ascent would be attended with danger. The greater part of the rock is a more or less ferruginous calcareous grit, much of which is dark blue on the fresh surface ; but the iron and lime are easily leached out, so that, on exposure, fragments become "rotten" to a depth of several inches. Some portions are very fine-grained and hard, so as to be fit for grindstones ; these are

well shown on a fork of Wolf creek, known as Whetstone hollow. A few of the beds are fossiliferous, but nothing can be obtained from a fresh piece, while the weathered specimens are so tender that specimens are ruined in the effort to free them from the rock. Huge stems of crinoids and some indistinct specimens of *Chonetes* were seen. The limestones are light blue, argillaceous and non-fossiliferous. The shales are usually reddish, but they form only a small part of the mass. No massive sandstone was observed here such as was seen in Pennington's and Big Stone gaps.

Nos. 2, 3 and 4 probably should be accounted as part of No. 1, but the shales, for the most part, are calcareous and resemble some lower beds more than they do those of Wolf creek. The shales, Nos. 8, 10, 12, 14, 16 and 18 are light blue to reddish blue on the fresh surface and weather to a dirty or muddy yellow. A fresh edge seldom shows lamination, but the weathered surface shows it distinctly. These beds are generally well exposed in the bed of Abraham's creek, along side of which the railroad grade runs. Fossils occur rarely in these shales, and the only distinguishable specimens seen belonged to a broad form of *Spirifera leidyi.*

The limestone, No. 5, well exposed at the roadside and in the hills at but a little way below the mouth of Wolf creek, is blue, but weathers yellowish white; it is composed chiefly of a *Fenestella*, but some layers have many specimens of *Athyris* and *Productus*. Nos. 7 and 15, both of which are well shown in the creek bed as well as in the hill, have a similar origin, and the *Fenestella* is distinctly shown throughout with only a rare *Productus* and *Zaphrentis*. These two beds are exceedingly hard. No. 15 is the same with that of which the bridge abutments for the Reedy Creek road were constructed at the North Fork of Holston river.

No. 6 continues from Mr. Kaylor's residence on Abraham's creek down the stream almost to his mill, at probably two-thirds of a mile from the river. It has more than one bed of limestone and is closed by a sandstone at the top. Below this interval, the section is almost continuous to the base of the series. No. 9 is shown at the mill; it varies from light to dark blue or almost black, and shows many stems of crinoids, with *Fenestella* and a *Spiriferina* closely allied to *S. kentuckensis*. No. 11 is a handsome light blue limestone and contains *Athyris subquadrata, Productus cora* and crinoid stems, which occur also in Nos. 17 and 19. No. 21 is an important bed, which is shown at the mouth of Abraham's creek and forms a broad band on the cliff around the bend of the river below the railroad bridge. For the most part, it is coarsely granular and dark gray, but it contains some argillaceous layers and becomes a blue grit near the base. It yields an admirable building stone, of which the bridge abutments and pier have been constructed. The rock is very pure and burns into a beautifully white lime, which shows no trace of iron when slaked.

No. 22 is argillaceous and its fragments cover the narrow bank below the bridge. This is by far the most fossiliferous bed of the whole series; *Productus cora, Productus elegans, Athyris subquadrata, Spirifera leidyi, Hemipronites crassus, Pinna* and *Allorisma* having been obtained from a

small block. Perhaps this should include also the concealed interval below it.

Nos. 24 and 25 are very similar to No. 21; they are granular, and No. 24 is massive. No. 25 is more or less flaggy, and passes into a hard, cross-bedded calcareous grit, which contains not a little chert.

The limits of the two groups are very distinct, and only a few feet at the bottom of No. 25 mark the transition. Below that line, chert is present in nearly every bed. Nos. 26, 27 and 28 are alike, except that very little chert occurs in No. 27. Many layers of No. 26 are crowded with bryozoans, and the smaller nodules of chert are casts of *Productus*. Crinoid stems are abundant in No. 28, which is massive and cherty throughout. No. 33 is well exposed in the railroad excavation: its higher beds are dark gray, streaked with white calcspar and contain much chert, some of which certainly has replaced a *Chætetes*-like form. Fossils occur in the highest beds, where sections of *Productus*, *Athyris* and *Pleurotomaria?* are abundant; the lower beds are massive, almost black, and show only minute fossils. No. 35 is very cherty in its upper and massive layers, but the lower layers are somewhat flaggy, show little chert, and are crowded with crushed fossils, chiefly *Hemipronites* and *Athyris*. No. 37 is flesh colored to light blue, and is well exposed at the mouth of a hollow nearly half a mile from the bridge over North Fork of Holston. There it describes a short abrupt anticlinal, which is nicely shown in the railroad side-cutting. This bed is the base of the upper member of the Silicious group.

No. 38 is the Protean member of the Silicious group. It is not fully exposed as the little hollow, already referred to, intervenes between the last exposure of the limestone and the first exposure of this mass, the concealed interval being perhaps 35 or 40 feet. But under the petty anticlinal, the upper part of No. 38 is shown within 5 feet of the limestone, the interval being filled with some drab clay, which may belong with either No. 37 or No. 38. The upper part of No. 38, as far as seen, is a fine-grained sandstone with smooth fracture, but this passes downward into shales containing a bed which is highly carbonaceous. The rocks below are fine-grained sandy shales with beds of blue calcareous sandstone or grit, very fine-grained and breaking with irregular fracture. These are very similar to the beds seen in No. 1 of the section. It is possible that *coal* occurs in the concealed part of this mass, for a *coal bed* is said to be present under the river directly opposite the mouth of the little hollow. The only fossil seen in these rocks was a fragment, which probably belongs to *Leiorhynchus*.

These beds rest comformably on the Chemung, as already stated.

The dip of the rocks varies. In No. 35 it is nearly 20 degrees; in No. 25 it is 33 degrees and the strike is N. 60° E. mag.; but here the rate increases, and in No. 24 it becomes 40 degrees, which is the prevailing rate of dip up to within 300 yards of the mouth of Wolf creek, beyond which no measurements were made. It is not at all improbable that a fragment of the Quinnimont group remains on the high land between Abraham's creek and Wolf creek.

The Holston uplift is reached at the summit between Wolf creek, North Branch, and the "rich valley" of Abraham's creek. There, one comes to the limestones of the Knox group, in contact with the highest rocks of the mountain limestone group, and two miles further along the railroad line the cherty beds of the Knox group are exposed. These are shown very near to Walker's mountain at a cross-road, where the soil is very ferruginous. The limestones of the overlying group are shown at but a little way from the gap by which the railroad passes through Walker's mountain.

A well-marked fault was crossed just behind Walker's mountain at somewhat more than four miles from Bristol, where the pyritous calcareous sandstones of the Knox group are shown in the gap through that ridge. The dip is abrupt at the head of the gap and increases to the mouth, where it becomes nearly 50 degrees, and the shaly layers are badly twisted. Exposures are very obscure between this locality and Bristol, where the line of section terminated; but the limestones of the Knox group are shown here and there, and the cherty beds of that group pass very near to Bristol.

Photodynamic Notes. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, January 21, 1881.)

1. *Chemical Synchronism.*

Maxwell* appears to have originated the theory, which is now generally accepted, of the equality of mean *vis viva* in the molecular movements of different gases, at equal temperatures. In 1863, I began to investigate some of the consequences of the theory, and the many evidences which I have adduced, of cyclical and harmonic vibrations in atmospheric and æthereal media,† have more than justified my belief of its importance.

All harmonies in elastic media necessarily involve some form of synchronism, and the progress of chemical physics may be helped by a knowledge of the general kinetic laws upon which such synchronism depends. If we designate velocity by v; density, by d; time of rotation, by t; modulus, by h; absolute temperature, by T; and the acceleration of a central force, by f, Maxwell's theory may be represented by the equation $v^2 d = k T$. In the fundamental equations of central force $v = \frac{f t}{2} = \mathrm{F} \sqrt{fr}$; $h = \frac{ft^2}{4}$. When the efficient or fundamental velocity is constant, as in spatial Photodynamics, $f \propto \frac{1}{t} \propto \frac{1}{h} \propto \frac{h}{t^2} \propto \frac{1}{r}$; $t \propto h \propto \sqrt{\frac{h}{f}} \propto r \propto \frac{1}{f}$; $h \propto r \propto \frac{1}{f} \propto ft^2 \propto t$. Whenever we have occasion to consider derivative or second-

* P. Mag., 1860 [4], 19, 19.

† Proc. Amer. Phil. Soc., ix, 284-7; xvii, 109-12, 294-307; xviii, 224-32; xix, 4-9 20-5; *et al.*

ary velocities, the equations of variation, for any temporary constancy of f, t, h or r, can be readily found. In the investigation of spectral lines, chemical atomicities, and general kinetic phenomena, both cosmical and molecular, the consideration of f as a maximum often becomes especially important. Then it is evident that $f \propto \left(\frac{r^3 d}{r^2} = r\,d\right)$; $t \propto \sqrt{\frac{r}{f}} \propto \sqrt{\frac{1}{d}}$; the limiting time, therefore, becomes independent of distance, and is merely a function of density. In other words, *in a homogeneous medium, all analogous motions which are due to the accelerations of a central force, whether of rotation, vibration or translation, are synchronous.* In whatever way those motions may be affected by atomic, or molecular rotation, $v \propto r$, without any tendency to the production of internal disturbance. All cyclical harmonies and deformations must, therefore, be due to elasticity, or some other form of translatory interaction. In consequence of the proportionality of rotating velocity to the distance from the centre of rotation, it becomes possible to combine chemical elements of the most various densities; for, while there is perfect synchronism in the normal oscillations of each of the elements respectively, the atoms may intersect with radii which give them equal velocities of rotation at the locus of intersection, so as to produce secondary and subordinate synchronisms, such as are indicated by the harmonies of spectral lines, especially in Lockyer's "basic lines"* and in the lines of the widely diffused and important elements, Oxygen and Hydrogen.† As an illustration of the harmonies of independent and combined synchronism, we may take the three atoms, H_2O, condensed into two atoms of watery vapor. In rotation, induced, either directly or remotely, by the fundamental efficient velocity of light, we have seen that $t \propto \sqrt{\frac{1}{d}}$ and $v \propto \frac{r}{\sqrt{d}}$; therefore $d\,v^2$ is constant, in each of the elements, and in the compound, *e. g.*:

$$O\left(d = 16;\ v \propto \frac{r}{4}\right) + 2\,H\left(d = 1;\ v \propto r\right) = 2\,H_2O\left(d = 9;\ v \propto \frac{r}{3}\right)$$

and four oscillations of O are synchronous with one of H and three of H_2O.

Such varied evidences of synchronism, both *a priori* and *a posteriori*, may well encourage specialists, in all departments of physical science, to seek for harmonies, under the guidance of the "scientific use of the imagination." We may be assured that such harmonies are abundant everywhere, and we may also be assured that whatever harmonies we find are neither fortuitous nor lawless, although we may, in some cases, be unable to find any other reasons for their existence than the universal canon of nodal action. The more we study the detailed and coördinated ramifications of such action, the greater will be our appreciation and admiration of the order which is "heaven's first law," and the more confidently we can go on with our researches.

* Proc. Amer. Phil. Soc., xviii, 225–6.
† Ib., xix, 25.

9. *Magnetism.*

One of the fields in which there seems to be encouragement for much special investigation, is Electro-magnetism. I gave many reasons, sixteen years ago,* for regarding all magnetic phenomena as results of locally modified vibrations, and on that account I have always thought it to be somewhat illogical to speak of light as "an electro-magnetic phenomenon," thus subordinating the general to the special. According to the law of parsimony, the element of a common velocity indicates a common origin in radiant energy, but in denoting that energy it seems better to use a name which is universally recognized as appropriate, than one which may probably represent a mere local phenomenon. Among my reasons for adopting this opinion was the delay in the manifestations of solar influence. Father Secchi observed a remarkable solar outbreak on the 7th of July, 1872, which produced a great agitation of terrestrial magnetism, and Airy estimated the time required for the propagation of the magnetic disturbance at 2h. 20m. This is 16.87 times the time required for light to come from the Sun to the Earth, which is almost precisely the ratio between the time of terrestrial rotation and the time of satellite revolution at the Earth's surface.

More than seven years after I had shown that the solar daily variations of terrestrial magnetism might be very closely represented, both in form and magnitude, by solar tidal action, Maxwell suggested the same hypothesis.† I showed, in 1875,‡ that my hypothesis led to a simple estimate of Sun's mass, which I placed upon record, without, however, giving all the data for the calculation. The total terrestrial magnetic force in Great Britain has been found to be 10gr. ft. sec.; then the tension, perpendicular to the lines of force, is .128 gr. weight per sq. ft. The greatest magnetic tension which Joule was able to produce in Great Britain, by means of electro-magnets, was about 140 lbs. weight on the sq. in. ($= 140 \times 144 \times 7000 = = 141120000$ gr. pr. sq. ft.). The unit of *vis viva*, in mechanical measure, varying as the square of the unit of velocity, is $m^2 l^2 t^{-4}$. But the molecular oscillation, in alternate approach to and recess from the orbital centre, continues for a half rotation or a half revolution, while the terrestrial antagonism lasts only $\frac{1}{\pi}$ as long. Therefore, if we designate Earth's mass by a subscript accent (m_1), the ratio of the magnetic force which is due to modified solar radiation, should bear the same ratio to the force of terrestrial reaction, as $m^2 l^2 t^{-4} : m_1^2 l^2 t^{-4} \pi^4$, or as $m^2 : m_1^2 \pi^4$. This gives the proportion $m^2 : m_1^2 \pi^4 :: 141120000 :: 128$, or $m : m_1 :: 327710 : 1$.

Although this result is nearly identical with the one deduced from the comparative leverage of Sun and Jupiter (327897), in the paraboloid of interstellar photodynamic action, I am inclined to think that it may be about one per cent. too small. When the difficulty of making precise magnetic

* Ib. Vol. ix, etc.

† Treatise on Electricity and Magnetism, ii, 127.

‡ Proc. Amer. Phil. Soc., xiv, 607–9.

measurements is considered, so slight a difference as this is hardly worthy of notice.

The experiments, which I performed before the Society in 1864 and 1865,* appear to have furnished the first direct and positive evidence of the hypothesis that electricity and magnetism consist simply of æthereal vibrations, which can be imitated and modified by simple mechanical means. This mechanical modification led, subsequently, to the invention of the telephone and the photophone.

8. *Earth's Orbital Eccentricity and its Correlations.*

The photodynamic importance of the centres of nucleation, condensation and nebulosity (Sun, Earth and Jupiter), in the solar system, and the tendencies to secondary and subordinate synchronisms, are further shown in moduli of rotation and in orbital eccentricities. The modulus velocity $\left(\frac{gt}{2}\right)$ of Jupiter is slightly greater, while that of Earth is slightly less, than Sun's wave velocity $(\sqrt{g_0 r_0})$; the slight differences being due, apparently, to the same causes as Earth's apsidal oscillations and its mean deviation from the centre of the belt of greatest condensation. Jupiter's secular range, from secular perihelion to secular aphelion $(.63295\rho_3)$, is nearly the same as Earth's orbital radius of spherical gyration $(\sqrt{.4} = .63245\rho_3)$; Jupiter's ratio of minimum eccentricity (.02549) is about three-quarters of Earth's ratio of mean eccentricity ($\frac{3}{4}$ of $.03387 = .02540$); at Jupiter's secular perihelion, or locus of rupturing oscillation, the projections of Sun's and Jupiter's centres from Sun's surface ($.93917 \times 5.2028 \times 214.55 = 1 + 1047.87$) are inversely proportional to their respective masses. We may, therefore, not unreasonably expect to find similar simple relations between different forms of terrestrial eccentricity and cosmical *vis viva*.

If we suppose the air to be condensed to the homogeneous density which is indicated by the theoretical velocity of sound, we may assign .4 of its velocity of equatorial rotation to the mean *vis viva* of simple spherical rotation, and the remaining .6 to æthereal or elastic action. The velocity of rotation is $2\pi \times 3962.8 \times 5280 \div 86164 = 1525.77$ ft.; the theoretical velocity of sound, $\sqrt{gh}$, should, therefore, be $.6 \times 1525.77 = 915.46$, and the height of homogeneous atmosphere $915.46^2 \div (32.088 \times 5280) = 4.9466$ miles.

This closeness of accordance with the values which have been derived from observation, accounts only for the equilibrium between the elastic and gravitating actions of daily rotation. The atmospheric particles, in their undulatory motion with the velocity of sound, may be regarded as traversing orbits with a mean eccentricity of $\frac{h}{r} = \frac{4.9466}{3962.8} = .0012483$. This result has been obtained by regarding the atmosphere as homogeneous, in the same way as our photodynamic results were obtained by regarding Sun's

* Ib., ix, 359; x, 151-66.

æthereal or luminiferous atmosphere as homogeneous. Therefore, if we consider Earth's mean orbital eccentricity as due to the elastic reaction of the nebular centre of oscillation (Jupiter) against the nucleal centre (Sun), we find :

Earth's mean atmospheric ecc'y : Earth's mean orbital ecc'y :: (Earth's semi-axis major)^2 : (Jupiter's semi axis major)^2; which gives .0012483 : .0033789 :: 1 : 5.2028^2. In order to acquire the velocity due to this eccentricity, there should be a fall of the centre of condensation (Earth) from the centre of the dense belt of planets, through one-half the height, or .016895 Earth's semi-axis major. In order to make the efficient wave producing *vis viva* at Earth equivalent to that at Sun's surface, we should take account both of Earth's (1.) and Jupiter's (.033789) action, as is done in the equation $1.033789 \frac{gt}{2} = \sqrt{g_0 r_0}$. Substituting $g = 32.088 \div 5280$, and $t = 86164$ sec., this gives 270.67 miles $= \sqrt{g_0 r_0}$. From this velocity we can readily deduce Earth's orbital velocity, which, being multiplied by the number of seconds in a sidereal year and divided by 2π, gives $270.67 \div \sqrt{214.55} \times 31558150 \div 2\pi = 92812000$ miles, for Earth's semi-axis major. The closeness of agreement between these photodynamic results and other estimated values is shown in the following table :

	Photodynamic.	Calculated from observation.		Difference.
Jupiter's secular range,	$.63245\rho_3$	Stockwell,	$.63295\rho_3$	.08 of 1 pr.ct.
" minimum ecc'y,	.02540	"	.02549	.36 "
Mass, Sun ÷ Jupiter,	1047.37	Bessel,	1047.88	.04 "
Theoretical vel. of sound,	915.46	Enc. Met.	916.322	.09 "
Homogeneous atmosphere,	4.9466	Silliman,	4.9478	.08 "
Earth's mean ecc'y,	.033789	Stockwell,	.0338676	.23 "
" " orbital fall,	.016895	"	.0169394	.26 "
" semi-axis major,	92812000	Cornu,	92803000	.01 "

4. *Cosmical and Molecular Densities and Velocities.*

We have seen that the function $t \propto \sqrt{\frac{r}{f}}$ is independent of any other element than d, when f is a maximum, or when comparisons are made at distances from the centre of force which are proportionate to their respective nucleal or atmospheric diameters. This renders the proportionality $t \propto \sqrt{\frac{1}{d}}$ an important one. For example, it is safe to predict that if the time of rotation of any single star should ever be discovered, it will be found to be such that $\frac{gt}{2}$ will not differ perceptibly from the velocity of light; and from the times of rotation we can readily calculate the ratios of stellar to solar density. In binary and multiple stars, or in planetary systems where the planetary reactions are so important as either to retard or accelerate the rotary velocity of the nucleal mass, the value of the modulus velocity must still be some function of the velocity of light, although it may be so changed as to leave room for much interesting and perplexing study in seeking the causes and amounts of perturbation. In considering

the equality of molecular *vis viva*, many well-known evidences of atomic and molecular rotation have been found, but I know of none which furnish the necessary data for determining in what way the intrinsic rotations, which are due to simple reaction against the undulations of the luminiferous æther, have been modified by the accelerations of terrestrial rotation and the various unknown mechanical influences of chemical physics. The molecular velocity $v \propto \sqrt{\frac{1}{d}}$ accounts for all synchronisms of homogeneous media, but how are we to explain the synchronisms of rotation and revolution in a body so heterogeneous, and, consequently, with such various moments of inertia, as the Earth? If density itself was originally a function of distance fallen through, and, therefore, varied as t^2, the synchronous time for the aggregate of mean motions varied as $\sqrt{d}$. The equation $s = vt$ is, therefore, constant for any given radius. In order that this constancy may prevail, there must be some unit of density to represent either the modified æther, or some gas which is directly subjected to the influence of its vibrations. The hyper-elasticity of hydrogen, its wide diffusion, its continual presence in the solar explosions, the fact that it has the greatest tenuity of any substance which we have been able to measure with precision, its importance in relation to Lockyer's "basic lines," together with the simple and significant harmonic indications of those lines,* all point to it as the probable typical representative, or the transmitter, of primordial undulation. In order to test this hypothesis, let x represent the specific gravity or d of Earth; 270.67 m., the value of $\sqrt{g_0 r_0}$ at Sun, or Earth's modulus velocity of rotation; 6050, the molecular velocity of hydrogen; .0693, the ratio of the specific gravity of hydrogen to that of air; 773, the ratio of the specific gravity of water to that of air; $x \div 1.033789^3$, the mean specific gravity of Earth if expanded to 1.033789 $\times$ its present radius, so as to eliminate the condensation due to the action of Jupiter. Introducing these values, in the constant equation $s = vt$, and considering v as the velocity acquired in t, the time of condensation, we have $\frac{270.67 \times 5280}{6050} = \sqrt{\frac{773\, x}{.0693 \times 1.033789^3}}$, and $x = 5.527$. The mean molecular velocity of earth which is due to æthereal elasticity, would then be $6050 \div \sqrt{\frac{773 \times 5.527}{.0693}}$ $= 24.367$ ft. pr. sec.; the corresponding velocity of any terrestrial substance $= \frac{24.367 \times \sqrt{5.527}}{\sqrt{d}} = \frac{57.284}{\sqrt{d}}$ ft., if the density is compared with that of water, or $\frac{57.284 \times \sqrt{773}}{\sqrt{d}} = \frac{1592.655}{\sqrt{d}}$ ft., if air at 0° and 760 mm. is taken as the unit of density. These ratios are important in investigations which involve the modified or specific elasticity of bodies.

* Proc. Amer. Phil. Soc., xviii, 224–6.

5. *Photodynamic Estimate of Earth's Mass.*

I have shown, in my discussion of "Earth's orbital eccentricity and its correlations" (Note 8), that Sun's surface is the fulcrum of equilibrium between the two principal masses of our system (Sun and Jupiter), at the locus of rupturing projection, or the secular perihelion centre of gravity of Sun and Jupiter. I also showed, in my first paper on photodynamics, that the antagonistic mean leverage of Sun and Jupiter produces disturbances, at the directrix-locus of the stellar solar paraboloids, which furnish a very close approximation to the ratio between solar and terrestrial superficial gravitating energy. The forces which have established these harmonies must act under special conditions of equilibrium at the centre of condensation (Earth), and it seems probable that those conditions may be less subject to extraneous disturbance than either of the other adjustments which I have investigated.

In the photodynamic paraboloids, at any given instant, let a be the solar locus of the directrix which is on the side of Sun's centre opposite to Earth; s_0, the centre of nucleation, or Sun's centre, regarded as a primary point of suspension for a linear pendulum; s_3, the centre of condensation, or Earth's centre, the secondary point of suspension of the same pendulum; o_0, the centre of a primitive nucleal radius and also the centre of linear oscillation for s_3; o_3, the centre of linear oscillation for s_0 and also the common locus for coördinate radii r_0 and r_3; o_1, the centre of the linear pendulum $s_0\, s_3$; o_2 the centre of $s_0\, o_0$ and the centre of linear oscillation of $o_1\, s_0$; $r_0 = s_0\, o_3$; $r_3 = s_3\, o_3$; m_0, m_3, homogeneous masses varying as r_0^3, r_3^3; o_3 is the locus, in suspension from s_0, of opposite tendencies towards s_3 and s_0. Then $r_0 = 2r_3$; $m_0 = 8m_3$; if we represent the superficial momentum of any equatorial particle of m_3 by 1×1, the corresponding momentum for m_0, with reference to the same point of suspension (s_3) is 8×3. If the photodynamic momentum is converted into velocity of contiguous particles, at o_3, causing one of the particles to revolve about s_3, and the other, by reaction from s_0, about s_0, their respective velocities will be represented by $\sqrt{g_3 r_3}$ and $\sqrt{g_0 r_0}$, the latter being $(8 \times 3 = 24)$ times the former. Now $\sqrt{gr} \propto \sqrt{\frac{1}{r}}$ while $g \propto \frac{1}{r^2} \propto (\sqrt{gr})^4$. Therefore $g_0 = 24^4 g_3$. But $g \propto m$, in mutual action and reaction, as in the case of Earth revolving and Sun rotating under the photodynamic influence of $gt = v_\lambda$; therefore $m_0 = (24^4 = 331776)\, m_3$. Radius varying as $\left(\frac{m}{d}\right)^{\frac{1}{3}}$, Sun's radius, r_0 should then be $(331776 \div .25527)^{\frac{1}{3}} = 109.07 r_3$; and Sun's mean distance, $\rho_3 = 214.5516 \times 109.07 \times 3962.8 = 92734000$ miles.

6. *Photodynamic Limitation of Terrestrial Day.*

The number and variety of the foregoing harmonies led me to look for some photodynamic influence on terrestrial rotation, or at the centre of density, analogous to that which is indicated by the solar nucleal equation,

at the centre of nucleation, $\frac{gt}{2}$ = velocity of light. The acceleration of sun spots near the solar equator indicates a velocity which is partly rotational and partly orbital. The solar corona is now generally attributed to nebulous or meteoric matter, which is constantly tending either to fall into or to revolve about the Sun. If Sun's surface is the locus of the mean orbital collisions, the mean nebulous radius is $\frac{8}{3} r_0$, and the mean locus of the nebulous particles, r_a, is $\sqrt{\frac{8}{3}} r_0$. Let t_a be the time of half-rotation for r_a, in the fundamental equation $g_a t_a = v_\lambda$; then $t_a = \sqrt{365.2565} =$ 19.11168 dy, is a mean proportional between the solar terrestrial day and the terrestrial year. This gives for t_0, or the photodynamic modulus time at Sun's surface, $\frac{2}{3} t_a = 12.741128$ dy. Let n = the number of solar radii (r_0) in Earth's semi-axis major (ρ_3), and we have the equations:

$$v_\lambda = g_0 t_0 = 12.741128 \times 86400 g = n\, r_0 + 497.827$$

$$g_0 r_0 = \left(\frac{n^{\frac{3}{2}} \times 2\pi\, r_0}{31558150}\right)^2 = n^3 r_0^2 + (5022080)^2. \quad \text{Hence}$$

$$n = 214.5516.$$

$$g_0 = .0000008915 r_0.$$

$$2\pi \sqrt{\frac{r_0}{g_0}} = 10041.8 \text{ sec.}$$

$$2\pi \sqrt{\frac{r_3}{g_3}} = 5073.6 \text{ sec.}$$

$$\frac{d_0}{d_3} = \left(\frac{5073.6}{10041.8}\right)^2 = \frac{1}{3.9174} = .25527.$$

$$r_0 = 92{,}812{,}000 \div 214.5116 = 432580 \text{ m.}$$

$$\frac{g_0}{g_3} = \frac{r_0 d_0}{r_3 d_3} = 27.8657.$$

$$\frac{m_0}{m_3} = \left(\frac{r_0}{r_3}\right)^3 \times \frac{d_0}{d_3} = 332{,}500.$$

Another evidence of the limitation of the time of rotation, at the centre of condensation, by photodynamic influences, is found in the accelerations which are due to condensation within the present limits of the solar system. The central actions and reactions of acceleration between Sun and Earth vary as their respective masses, because $g \propto \frac{m}{d^2}$ and d is the same. In condensing nebulæ, equality of *vis viva* requires that t (of rotation) $\propto r^2$. From this source, therefore, Earth has been accelerated $(30.034)^2$ times by its "subsidence" from Neptune's mean orbital distance. This acceleration provides only for synchronous solar and terrestrial rotation; there has, however, been a further acceleration of 366.2565, by the shortening of the solar year to the terrestrial day, and of $\sqrt[4]{1.0145}$ by the mean

"subsidence" of Neptune from its secular aphelion, since $\frac{1}{3}\, gr \propto \frac{1}{3}\, g$. The quotient of Sun's mass by Earth's mass which will account for all these accelerations, is therefore, $\frac{4}{3}$ 1.0145 × 366.2565 × (30.034)² = 331567, a value which differs by only $\frac{1}{16}$ of one per cent. from the one last obtained by purely *a priori* indications, and $\frac{1}{4}$ of one per cent. from the one which was deduced from coronal oscillations.

7. *Photodynamic Limitation of Jupiter's Day.*

The centre of nebulosity (Jupiter) presents equally conclusive evidence of photodynamic acceleration, if we pay proper regard to the difference between the expansive reaction of elasticity and the gravitating action of condensation, with its consequent limitation of elasticity. If we take the "centre of primitive annular condensation" (Neptune), at its rupturing locus (secular perihelion = 29.5982$_{r_0}$), the photodynamic seat of rupturing action* is at $\frac{5}{9}$ of 29.5982$_{r_0}$ = 16.4434$_{r_0}$; squaring and multiplying by Sun's mass (1047.879), we get 10467 for the number of rotations in an orbital revolution. Dividing Jupiter's year (4332.5848 dy) by 10467, we get 9h. 56m. 3.4s. for the length of Jupiter's day. Prof. Hall's recent estimate is 9h. 55m. 26.5s.

8. *Moon's Mass.*

In the third note of the present series, I have shown some of the relations of Earth's orbital eccentricity to Jupiter's locus of rupturing oscillation, the masses of Sun and Jupiter, Earth's fall from the centre of the belt of greatest condensation, and the height of Earth's homogeneous atmosphere. The atmospheric elasticity should evidently be in equilibrium, between the mutual inter-actions of Earth and Moon, in the same way as the ethereal elasticity is in equilibrium between solar and planetary actions and reactions. The atmospheric eccentricity being .0012483, the ratio between the lunar and terrestrial masses, in order to be in equilibrium with this eccentricity, should be π^2 × .0012483, or Earth's mass should be 81.17 times Moon's mass. What slight modifications of this value may be required, in order to satisfy other conditions, must be left for further investigation.

9. *Earth's Semi-axis Major.*

If we take the photodynamic estimate of the centre of the belt of greatest condensation (1.016895; Note 3), the ratio of r_a to r_0, as determined by the mean locus of solar and terrestrial action proportionate to mass, should be 1.016895 times $\frac{214.5516}{2}$ = 109.088. If we adopt Stockwell's computation of the secular centre of the belt of greatest condensation (1.016939$_{r_0}$), the ratio is 109.093. These estimates give, for Earth's semi axis major, 92750000 and 92754000 miles respectively.

* Proc. Amer. Phil. Soc., xii, 392-4; P. Mag., June, 1877, p. 353.

10. *The Photodynamic Year.*

The constant action of the constant photic energy, at the centre of solar and terrestrial action proportionate to mass, is equally divided between Earth and Sun, so that $g_3 t_3$ for Earth corresponds with $\frac{g_0 t_0}{2}$ for Sun, when so expanded that its rotation would be synchronous with the terrestrial year. We therefore find for the velocity of light, if we allow for the acceleration due to the photodynamic projection of Neptune (Note 6),

$$\frac{g \times 1 \text{ yr. in sec.}}{(\text{Neptune's projection})^2} = \frac{32.088 \times 31558150}{5280 \times 1.0145^2} = 186345 \text{ miles per sec.}$$

Multiplying by 497.827, the time required for light to come from the Sun, we get 92,767,260 miles for Earth's semi-axis major.

11. *Masses of Jupiter and Saturn.*

In consequence of the simplicity of Earth's relation to the centre of condensation, the *a priori* approximation to its mass is comparatively easy; but all the requirements of photodynamic *vis viva* must be satisfied in each of the cosmical masses, as well as in every chemical atom and molecule. Jupiter's synchronous radius, or the distance from Jupiter's centre ($.51231\rho_3$), at which a satellite would revolve in one of Jupiter's orbital revolutions, is 1.0246 × the radius of confluent solar and terrestrial mass action. The time of any circular orbital revolution is ($\sqrt{32} = 5.6568$) × the time of fall to the centre of force. The accelerations of gravity varying as the fourth power of orbital velocity, and acquired velocity varying as gravitating time, the mass, which would satisfy conditions of simple equilibrium between tendencies to condensation and to orbital motion, is $5.6568^4 = 32^2 = 1024$. Sun's mass : Jupiter's mass :: 1047.879 (= 1.0234 × 1024) : 1. This indicates a modification of the equilibrating mass, similar to the modification of the synchronous radius. The difference between 1.0234 and 1.0246 is less than one eighth of one per cent., which is within the limits of probable errors of observation. The rupturing photodynamic ratio ($\frac{9}{8}$; see Note 7), and the ratio of photodynamic projection (1.01455;* see Note 10), have both been introduced, as factors of equilibrium, between the centre of nebulosity (Jupiter) and the nebular centre of planetary inertia (Saturn);† for $(\frac{9}{8} \times 1.01455)^2 \times 1047.879 = 3501.6$ which is Bessel's estimate of the quotient of Sun's mass by Saturn. This deduction of Saturn's mass, therefore, indicates (Note 10) a velocity of light equivalent to $\frac{32.088 \times 31558150}{5280 \times 1.01455^2} = 186326$ miles, and gives, for Earth's semi-axis major, 92,758,000 miles.

12. *Photodynamic Centre of Planetary Inertia.*

Saturn's position, at the nebular or photodynamic centre of planetary inertia, furnishes special and very interesting crucial illustrations of the

* This value is about $\frac{1}{75}$ of one per cent. greater than Stockwell's estimate of that of Neptune (1.0145066).

† Proc. Am. Phil. Soc., xviii, 431.

cosmical influence of harmonic nodes in an elastic medium. Let v_λ be the velocity of light; g_x, the acceleration of gravity at r_x, the radius of Sun's photodynamic sphere; $v_x = \sqrt{g_x r_x} =$ orbital velocity at r_x; $v_0 =$ orbital velocity at r_0 (Sun's surface), and modulus velocity, $\left(\frac{gt}{2}\right)$, for centres of nebulosity and of condensation (Jupiter and Earth), the modulus velocity having been slightly changed, as we have seen, by forces which produce orbital eccentricity; $M_x = \frac{g_x t_x^2}{4}$; r_1, radius of orbital revolution synchronous with nucleal rotation; $\left(\frac{v_\lambda}{v_x}\right)^2 = \frac{M_x}{r_x} = \frac{g_x t_x^2}{4 r_x}$; $M \propto r_x^2 \propto r_1^{\frac{3}{2}}$; $r_1 \propto r_x^{\frac{4}{3}}$; $r_2 = \sqrt{r_x r_1} \propto r_x^{\frac{7}{6}} \propto r_1^{\frac{7}{8}} \propto M^{\frac{7}{12}}$; $r_2^{\frac{12}{7}} \propto M$; $r_2^{\frac{6}{7}} \propto M^{\frac{1}{2}} \propto \frac{1}{v_x} \propto \frac{1}{v_2} \times \left(\frac{r_x}{r_2}\right)^{\frac{1}{2}} \propto \sqrt{r_0}$. If we take r_0 as the unit of distance, we have, for the present condition of the solar system, $r_x = \sqrt{M r_0}$; $\left(\frac{r_2}{r_0}\right)^{\frac{6}{7}} = \sqrt{\frac{M}{r_0}} = \frac{v_\lambda}{v_2} \times \left(\frac{r_0}{r_2}\right)^{\frac{1}{2}}$; therefore $\left(\frac{r_2}{r_0}\right)^{\frac{19}{14}} = \frac{v_\lambda}{v_2} = \frac{t_2}{t_\lambda}$. But $\frac{t_2}{t_\lambda} =$ the time in which light would traverse Saturn's orbit, divided into the time of Saturn's orbital revolution; therefore $\left(\frac{r_2}{r_0}\right)^{\frac{19}{14}} = 9.5389^{\frac{3}{2}}$ years $\div$ ($9.5389 \times 2\pi \times 497.825$ seconds) $= 31160.4$; $\frac{r_2}{r_0} = (31160.4)^{\frac{14}{19}} = 2046.8$. This gives for Earth's semi axis major $\frac{2046.8 r_0}{9.5389} = 214.575 r_0$.

13. *Earth's Rupturing or Projectile Locus.*

In Note 6, I have shown the relation of Earth's accelerated rotation to Neptune's subsidence and Sun's mass. In Note 5, I deduced a value for Earth's mass from simple considerations of linear oscillation, between the nebular centre of the solar system and the centre of greatest condensation. Since the stability of the system requires that all its oscillations should be harmonic, we may also account for Earth's rotary acceleration by simple solar and terrestrial inter-actions. The propagation of rays of equal length, in an elastic medium, produces a terrestrial reaction to its orbital motion, through a radius equal to Sun's radius. The centre of linear oscillation, in terrestrial revolution, which limits the tendencies of photodynamic *vis viva* towards the earth, is at only $\frac{1}{8}\rho_3$ from Earth, or near Venus's secular perihelion; the pendulum of solar action upon Earth (ρ_3) is three times as great. The sum of the masses of Earth and Sun being involved in these actions and reactions, there is a consequent acceleration which would give the Earth nine rotations per annum from this source alone. This acceleration is further increased by the rela-

tions of orbital velocity, due to Sun's mass acting through Earth's secular perihelion or projectile radius vector, which may be represented by $\sqrt{\frac{m_0}{\rho_3}}$, and to Earth's mass acting through a radius equal to Sun's semi-diameter, which may be represented by $\sqrt{\frac{m_3}{r_0}}$. Therefore we have the proportion $\sqrt{\frac{m_0}{\rho_3}} : \sqrt{\frac{m_3}{r_0}} :: 866.2565 : 9$. Hence $\frac{m_0}{m_3} = \left(\frac{866.2565}{9}\right)^2 \times \frac{\rho_3}{r_0}$. Introducing Stockwell's ratio for Earth's projectile radius vector (.9822648) we find $\frac{\rho_3}{r_0} = .9822648 \times 214.5516 = 200.02$, and $\frac{m_0}{m_3} = 331252$.

14. *Callisto, Jupiter's Telluric Moon.*

The combined influence of harmonic photodynamic oscillations on the three important centres, of nucleation (Sun), condensation (Earth), and nebulosity (Jupiter), is further shown by the proportion :

Jupiter's isochronous radius : Callisto's semi-axis major :: $\sqrt{\frac{m_0}{\rho_3}}$ $\sqrt{\frac{m_3}{r_0}}$ :: 866.2565 : 9. Searle* gives for the distance and period of Callisto, $.012585\rho_3$ and 16.689 days. This would make Jupiter's isochronous radius $.012585\rho_3 \times (4332.5848 \div 16.689)^{\frac{2}{3}} = \frac{866.2577}{9} \times$ Callisto's semi axis major $= .51231\rho_3$. The value thus obtained for Earth's sidereal year differs from the observed value by only $\frac{1}{3000}$ of one per cent. Other harmonic influences, analogous to those which we have already considered, are traceable in the following equations: 1. $\left(\frac{2}{3}\right)^4 \times$ Jupiter's mean aphelion projection $\times$ Earth's day $=$ Jupiter's modulus time, or time of half rotation. This gives, for Jupiter's day, 9h. 53m. 26.5s. 2. $\frac{2}{3} \times \frac{\text{Jupiter's semi-axis major}}{\text{Earth's semi-axis major}} \times$ time of revolution at Jupiter's surface $=$ 9h. 54m. 11.6s. 3. $2^4 \times 1.04316 \times$ Jupiter's semi-diameter $= 16.69056r =$ Callisto's semi-axis major. 4. $3^3 \times$ Earth's day $=$ Callisto's orbital time (26.9984 dy). 5. Jupiter's modulus velocity $\div$ Earth's ratio of aphelion projection (1.0677352) $=$ 271.28 miles. This gives 186830m. for the velocity of light, and 93010000m. for Earth's semi-axis major.

15. *Probable Values.*

I subjoin, for comparison, a few of the results of the foregoing methods of questioning nature, under the simple guidance of the well-known law that every action *must have* an equal and opposite reaction. The dates refer to publication in the Proceedings of the American Philosophical Society.

Flame energy,	Feb. 16, 1872,	92639500
Basic lines,	April 4, 1879,	93208000

* Outlines of Astronomy, Sect. 795.

Earth's orbital unit,	April 4, 1879,	92379000
Cosmical masses,	" "	92549000
Neptune's radius vector,	" "	92717000
Primitive condensation,	Jan. 4, 1880,	92520000
Sun and Jupiter,	" "	92606000
Nodal action,	March 19, 1880,	92711850
Hydrogen,	April 16, "	92756000
Oxygen,	" "	92849000
Undulatory *vis viva*,	Note 3,	92812000
Earth's mass,	" 5,	92734000
Terrestrial day,	" 6,	92714000
Earth's semi-axis major,	" 9,	92752000
Earth's year,	" 10,	92767260
Jupiter and Saturn,	" 11,	92758000
Earth's projection,	" 13,	92590000
Jupiter's day,	" 14,	93010000

These combined results indicate a value, for Earth's semi-axis major, of 92737100m. ± 25700; the probable error being less than $\frac{1}{36}$ of one per cent. This gives, for the velocity of light, 299854 ± 83 kilometres. In the *American Journal of Science*, for January, 1880, pp. 59–64, D. P. Todd discusses Foucault's, Cornu's and Michelson's experimental estimates of the velocity of light. The following table gives his several values, together with Michelson's final estimate (III), and my own:

Foucault	298000 km.
Cornu, I	298500 "
" II	299990 "
Michelson, I	300100 "
" II	299930 "
" III	299820 "
Todd	299920 "
Chase	299854 "

Stated Meeting, February 4, 1881.

Present, 9 members.

Vice-President, Mr. Eli K. Price, in the Chair.

Letters accepting membership were read from Dr. Chas. Stewart Wurts, 1701 Walnut St., Jan. 24, 1881; Mr. Henry Carvill Lewis, Germantown, Jan. 25, 1881; Capt. E. Y. McCauley, Lima, Delaware Co., Pa., Jan. 26, 1881; Mr. Addison May, West Chester, Pa., Jan. 26, 1881; and Prof. Joseph Lovering, Cambridge, Mass., Jan. 31, 1881.

Letters acknowledging receipt of Diplomas were received from Dr. E. H. Von Baumhauer, Haarlem, Jan 15, 1881; U. G. Armstrong, Newcastle-upon-Tyne, Jan. 13, 1881; and Sir Wm. Thomson, Glasgow University, Jan. 19, 1881.

A photograph of Dr. Benjamin Howard Rand was presented for insertion in the Album.

.Letters of acknowledgment were received from the Astronomical Society at Leipsig (106 and List); and the American Statistical Association, 19 Boylston Place, Boston (106).

A letter of envoy was received from the Meteorological Office, London, Jan. 1881.

A request for missing Nos. 88, 105 and after, from the Cambridge Philosophical Society, England, was, on motion, referred to the Secretaries with power to act.

A request for Transactions Part 3, Vol. XV, for the Numismatic and Antiquarian Society of Philadelphia, was referred to the Secretaries with power to act.

A letter from the Société d'Anthropologie de Paris requesting subscriptions to the Paul Broca monument was read.

Donations for the Library were received from the Senckenburg Natural History Society, Frankfurt a. M.; the Zoologischer Anzeiger, Leipsig; Nassau Natural History Union; Academia dei Lincei; Annales des Mines, and Revue Politique, Paris; Société de Geographie Commerciale, Bordeaux; Meteorological Council and Nature, London; Geological Survey of Canada; Institute of Technology, Boston; Museum of Comparative Zoology and Harvard College Library, Cambridge; American Journal of Arts and Sciences, New Haven; Numismatic and Antiquarian Society, College of Pharmacy, Mr. F. T. Freeland and Mr. Henry Phillips, Jr. Philadelphia; Mr. Thos. H. Dudley, Camden; Historical Society of Delaware, Wilmington; the Bureau of Education, Washington; and the Kansas Historical Society.

Dr. Brinton read an obituary notice of Prof. S. S. Haldeman, a member of the Society.

Prof. J. J. Stevenson communicated a paper entitled "The

Upper Freeport Coal Bed along Laurel Ridge in Preston county of West Virginia." By John J. Stevenson, Professor of Geology in the University of the City of New York.

Mr. Fraley reported by letter that he had received and paid over to the Treasurer the last interest on the Michaux Legacy due Jan. 1, 1881, amounting to $129.60.

And the meeting was adjourned.

The Upper Freeport Coal Bed along Laurel Ridge in Preston County of West Virginia. By John J. Stevenson, Professor of Geology in the University of the City of New York.

(*Read before the American Philosophical Society, February* 4, 1881.)

Laurel ridge, the easterly boundary of Ligonier valley in Pennsylvania, enters West Virginia at or very near the north-western corner of Preston county. It is a bold anticlinal, which in Indiana, Westmoreland and Fayette counties of Pennsylvania, as well as in Preston and Barbour counties of West Virginia, exposes the bottom of the Lower Carboniferous, and at some localities brings up the Chemung rocks, while the Conglomerate and the Lower Productive Coal group, the Allegheny series of Lesley, are shown on its sides. The fold is cut transversely by several deep gaps in Pennsylvania, where it shows no longitudinal valleys of considerable extent; but in Preston county of West Virginia it is divided longitudinally by Cheat river, whose gorge is one of the most noteworthy attractions of the Baltimore and Ohio railroad.

A strip, extending nearly twelve miles along the westerly slope of the ridge in Preston county, and divided by the Baltimore and Ohio railroad, was visited by the writer in December of 1880. The *Upper Freeport Coal Bed*, the most important member of the Lower Productive Coal group, presents some features there which may be deserving of note.

The easterly outcrop of that bed is crossed by the railroad at probably two miles eastward from Tunnelton station, and there, on the Graham-Beall estate, an old opening was examined which showed the following section:

1. Mahoning sandstone	not measured
2. Shale	0′ 3″
3. *Coal*	3′ 10″
4. Clay	0′ 2″
5. *Coal*	1′ 8″

But the exposure at the bottom is not complete, for, underlying the measured portion, is some good coal, and still lower is a considerable thickness of impure slaty coal, which is not worth digging. The coal, as far

as exposed, is very good, more or less prismatic, very soft and easily mined. For the most part, it is clean, but thin streaks of pyrites occur in the top 10″, and minute scales of the same mineral appear occasionally in the bottom 8″. Above the coal and separated from it by but 2 or 3 inches of shale is the hard gray Mahoning sandstone, which lies in thick beds and forms an excellent roof. The exposure of this rock does not give the thickness.

The sandstone is well shown along the railroad between this place and Tunnelton. Owing to the crookedness of the road, the bottom of the rock is sometimes below, sometimes above the track, but rarely many feet in either the one way or the other. Frequently, however, the coal is at track level, and at Tunnelton it is far enough above that to be worked. It descends toward the tunnel beyond the station, but in the tunnel rises again so as to form the roof at the westerly end. Thence, however, the course of the road follows the dip of the rocks, and the coal soon comes down to the track-level, where it is mined and shows the following section :

Coal	2′ 8″
Clay	0′ 2″
Coal	2′ 8″

The exposure is incomplete at the top, but reaches very nearly to the bottom of the good coal. The slaty division below is said to be not far from 3 feet, in which case the full thickness of the bed is about 9 feet 6 inches. The quality of the measured coal here is similar to that of the coal seen at the Graham-Beall pit. Eight inches of the slaty coal were seen. It contains some good splint, but for the most part appears to be worthless. The roof at this pit is shale, which varies in thickness from 2 inches to 12 feet; but it is hard, and makes a very good roof. The Mahoning sandstone is shown in the hill above this pit.

Within one-fourth of a mile from this opening, the railroad crosses a deep gorge, in which the coal bed is exposed below the track with several feet of shale between it and the Mahoning sandstone, which forms a bluff on each side of the gorge. The thickness of the shale varies abruptly, and the limits seem to be as given above. From this ravine, the coal rises until at Austin station it is above the track, and at half a mile further it is mined and coked by the Austin Mining Company.

The outcrop of the bed is easily followed southward from the railroad, and lies at but a little way eastward from the ridge-road leading from Tunnelton to the Northwestern turnpike. The coal is reached at that pike. Few of the ravines thus far are deep enough to expose the coal, but that through which Sandy creek runs affords good exposures, and the bed had been opened at several places along that stream.

Beyond the point where the ridge road reaches the pike, at say five miles from Tunnelton, the ravines become deeper and exposures of the bed are numerous. Pits were seen on several farms. In this direction, the bed becomes thicker though it seems hardly to improve in quality. One opening, seen on Mr. Wolf's farm at about eight miles from Tunnelton, shows 11

feet of coal without any persistent parting, though there are many insignificant partings which continue for but a few yards. The coal appears to be more sulphurous here than it is nearer the railroad, and the ash is greater.

The bed was followed northward from the railroad for several miles, but its structure there is similar to that seen in the pits on the railroad.

The dip throughout is north-westward, and the undulations with respect to the track are due to curves in the railroad.

The especial feature of the bed here, aside from its thickness, is its freedom from sulphur. In the Ligonier valley of Pennsylvania, according to Mr. McCreath's analyses, the sulphur in *Upper Freeport coal* varies from 1.414 to 4.789, and the coal rarely yields a firm coke. The ash varies from 3 to 6 per cent. Further south, in Upshur and Randolph counties of West Virginia,* the sulphur is high, and the ash is considerable even when the coal is best.

Within the area immediately under consideration, the coal from this bed yields an excellent coke. The Austin Company has found a ready market for its product, which in Chicago competes on even terms with the Connellsville coke. Several car loads of coal from the vicinity of Tunnelton were sent to Connellsville and there coked. Two lots were sent to the Cambria Iron Works, where analyses were made by Mr. Morrell with the following results:

Car No. 1, made from *sound coal*:

Carbon	92.64
Sulphur	0.53
Ash	6.82

Car No. 2, made from *outcrop coal*:

Carbon	88.05
Sulphur	1.41
Ash	10.54

Coke made from coal obtained at another opening was sent to the Edgar Thompson Steel Works, where it was analysed by Mr. S. A. Ford, with the following results:

Fixed carbon	88.163
Volatile matter	0.873
Sulphur	0.837
Ash	10.125

These tests seem to have been sufficiently extensive to determine the value of the coal for coking purposes. The loss in coking, as reported by Mr. M. L. Schaefer, Superintendent of the Austin Company, is about 33 per cent, indicating a composition very nearly like that of the *Pittsburgh coal bed* in the Connellsville basin.

* For description of the bed in these counties, see *Notes on the Geology of West Virginia*, by the writer, read before this Society on February 3, 1873.

It is evident then that the *Upper Freeport coal bed* in this region will yield a coke which is not appreciably inferior to that made at Connellsville, Pennsylvania.

Few details were gathered respecting the general section exposed along the slope of Laurel ridge, as all detailed work was stopped by a severe snow storm. A bed of cannel was seen at not far from 165 feet above the *Upper Freeport*. On one side of Sandy creek, this bed shows 4′ 8″ of cannel, but on the other side of that creek it shows no cannel, and contains only bituminous coal, 3′ 6″ to 4′ thick. The cannel was worked many years ago for distillation of oil, but the works were abandoned on the discovery of petroleum.

The Freeport limestone is present at from 40 to 50 feet below the *Upper Freeport coal bed*, and is exposed at one locality nearly three miles north from the railroad. It is 3 feet thick, and rests on a bed of iron ore, which is 30 inches thick and very persistent. This ore was mined at one time both by benching and drifting, and the material was sent to the Irontown furnace, where it produced a foundry iron. It is too cold-short for use alone, and to be available must be mixed with some ore containing little or no phosphorus. A small coal bed rests on the limestone, and another, about 2 feet thick, is shown at nearly 70 feet lower.

Memoir of S. S. Haldeman, A. M., Ph. D., etc. By D. G. Brinton, M. D.

(Read before the American Philosophical Society, February 4, 1881.)

In presenting a sketch of the life of the late Professor Haldeman, I shall begin with his personal history, and then proceed to give a brief account of his contributions to science.

Samuel Stehman Haldeman was born August 12, 1812, at Locust Grove, a beautifully situated country-seat on the east bank of the Susquehanna river, twenty miles below Harrisburg. The house, with the extensive property surrounding it, had been in the possession of his ancestors for several generations.

The family came originally from Thun, in German Switzerland, and were an energetic, independent race, who had been honored in their day. Jacob Haldeman, a great-grandfather of the subject of this memoir, was chosen one of a Committee of Public Safety from Rapho township, Pa., in revolutionary times. Frederick Haldimand, a great-uncle who had entered the English military service, became first Governor-General of Canada under that rule. John B. Haldeman, a grandfather, was member of the General Assembly from Lancaster county, in 1795. The name was formerly spelled with either *i* or *e* in the second syllable and the final *d* rejected or retained according to the language of the canton in which it was found, but as it was of Germanic origin, Prof. Haldeman always used the German method.

He was the oldest of seven sons, his parents being Henry Haldeman (1787–1849) and Frances Stehman (1794–1826). His father, a lover of books, endeavored to foster in this, his favorite child, a desire for learning, and to impress upon him its importance. His mother, a lady of attainments, dying when he was but twelve years old, had but little influence upon his after career, except perhaps that his great accuracy in detecting and analyzing unusual sounds in language may have been inherited from her who was an accomplished musician. His early education was pursued at the local schools, supplemented by a good library at home. The favorable opportunities for the observation of nature which presented themselves he improved by forming a boyish museum containing rude anatomical preparations made from rabbits, opossums, muskrats, etc., and of birds, which a traveling Methodist preacher had taught him how to stuff. An extract from a letter to a friend, dated 1844, contains these words, "I collected shells on the banks of the Susquehanna long before I knew the meaning of genus and species."

In the spring of 1826, when nearly fourteen years of age, Mr. Haldeman was sent to the Classical Academy of Dr. John H. Keagy, at Harrisburg, Pa., a gentleman of whom he always spoke as being an able thinker and thorough scholar. An assistant teacher, Mr. J. T. Q. Mittag, who is yet living at an advanced age, refers with enthusiasm to the precocity and studious habits of his pupil at that time.

He remained at Harrisburg two years, and then went to Dickinson College, Carlisle, Pa., where his taste for natural science was encouraged by Prof. H. D. Rogers, subsequently the distinguished geologist. But his early freedom and the bent of his own sturdy genius made the restraints of a college course irksome, and after two years he left Carlisle without waiting to obtain a degree and with the intention of pursuing his studies alone. In fact, the lack of thorough teaching in his youth had given him a rooted distrust for the opinions of the masses, and had formed habits of self-reliance which forced him to be original or nothing. "I cannot learn from others, I must see for myself," he would impatiently exclaim, and thereupon would proceed to investigate an assertion with a series of cross-examinations such as were well calculated to develop the exact truth. In after years, to see some poor native under the fire of his questions, when the pronunciation of an *a* or an *u* was at stake, was almost painful. His horror of compilers was such that once when returning from Europe, being reproached for having written such short letters "when seeing so much to write about," he characteristically referred the speaker to an excellent work on European travel, saying that as everything had been well described there, it was not worth while to repeat it.

Thus at the age of eighteen he began to direct his own studies and to accumulate at the paternal mansion cabinets of geology, conchology, entomology, botany and a scientific and linguistic library. As the bias of local opinion rendered it necessary that all young men who were not professional should go into business, he assisted his father in conducting a saw-mill on

a newly acquired property, called at that time Chickiswalungo. The young student found business even more tedious than college routine, and relates of himself at this time, "I developed a taste for rainy weather and impassable roads; then I could remain undisturbed in the perusal of my books, a supply of which I kept in a back office, where I retired as soon as the sky looked threatening." This taste for rainy days was not fictitious and remained with him during his life.

In 1835, Mr. Haldeman married Miss Mary A. Hough, a lady whose eminent qualities and devotion to his interests greatly aided to render his after success possible. Ably taking upon herself those cares which a growing family entail, she left him leisure for the pursuit of his favorite projects, and it was in consequence of her wish that he wrote his essay on *Analytical Orthography*, which, though not more important than his other works, gained him an European reputation.

Shortly after his marriage, Mr. Haldeman, with his wife, occupied the residence built for him by his father at Chickies, and became a silent partner in the iron business conducted by his brothers, Dr. Edwin and Paris Haldeman. Here books and cabinets accumulated under his laborious hands, only to be scattered again and give place to others when his insatiable appetite for knowledge led him into new fields of investigation. For forty-five years he spent most of his time in his library, where in his vigorous manhood he worked sixteen hours a day. For though he accepted several professorships and delivered a number of courses of lectures, he did so with reluctance, preferring to be master of his time and to spend it in the quiet of home.

In person, Mr. Haldeman was of middle height, with small, well formed hands and feet, a large and remarkably round head, giving great breadth across from ear to ear; high forehead, Roman nose, full lips, black eyes, and in youth a quantity of black hair, which at his death was of snowy whiteness. Long before it was usual in America he wore a moustache and beard, not for adornment but for convenience. In speaking, he had a clear enunciation, penetrating voice, and much readiness at repartee. His movements were rapid, his disposition cheerful, his general health excellent, and his interest in science unflagging to the end of his life, his latest occupation for leisure moments being the forming of an archæological collection, in which he took great pleasure, and the advancement of the spelling reform.

His death took place suddenly at seven o'clock, Friday evening, September 10, 1880. On returning from the meeting of the American Association for the Advancement of Science, held at Boston, August 23d, he complained of fatigue, but insisted on occupying his library as usual. A physician being sent for advised rest, but it was only on Friday morning that he could be induced to keep his bed. The physician paid him a long visit on Friday afternoon, and Mr. Haldeman conversed cheerfully for about an hour; only once he complained of weakness, and fixing his eyes on the doctor, asked, "Do you think this could be the breaking up of my sys-

tem?" but seemed satisfied when the doctor, surprised, answered "No." A few hours afterward, having risen from his bed without assistance, his son, who was in the next room, heard a fall; in a moment he was by his side and had taken him in his arms, but though every means was resorted to that animation might be restored, life had departed. Death was occasioned by a disease of the heart, to which he had some hereditary predisposition.

I may add to the above some personal reminiscences illustrating Prof. Haldeman's character, communicated to me by Prof. E. A. Barber, of this city.

Like most men of high impulse and native truthfulness, it was difficult for him to suspect deceit in others. On one occasion he showed Prof. Barber a small stone ornament shaped like a fish, and enthusiastically described it as one of the "finds" in the famous "Chickies rock retreat." With some hesitation his auditor pointed out certain suspicious marks about it, and suggested the possibility that it had been manufactured by one of the boys engaged in the excavation. For the first time the idea of such an imposition crossed his mind, and further investigation led to a confession of the act by the perpetrator.

It was his taste and apparently also his theory that a student should not be a specialist, but should devote his mind to different branches, thus securing wider knowledge. In a conversation with Prof. Barber, he once said: "I never pursue one branch of science more than ten years, but lay it aside and go into new fields."

As a correspondent, he wrote frequent letters, but brief ones, and generally was an enemy to prolixity. In one of his letters he writes, "You may think the enclosure rather short, but I dislike palaver, and like to say my say, then stop."

This trait shows itself in his writings. His style is terse and nervous, and his matter shows constant evidence of careful arrangement, so as to secure the utmost condensation compatible with clearness.

Professor Haldeman's religious views were fixed for many years before his death. Born of Protestant parentage, he was led in early life to doubt the theology which he heard taught in the schools and preached in the pulpits of Central Pennsylvania, and for a term of years did not attach himself to any sect or church. Later on he took up the systematic study of the evidences of religion, convinced that this is a subject on which every man of intelligence should have definite and defensible convictions. The result of his studies was that he united himself with the Roman Catholic Church, which he stated he had found to be the earliest historic form of Christianity, and he remained a consistent member of that confession until his death.

Early distinguished as a devoted student of natural science, Prof. Haldeman was selected to fill various public positions as an expert and a teacher. In 1836 he was chosen an assistant in the New Jersey Geological Survey, and the following year held a similar office in Pennsylvania, and

prepared a work on the geology of that part of this State lying between the Blue mountain and South mountain, from the Delaware to the Maryland line, which was published May 1st, 1837. While engaged in this occupation he discovered the *Scolithus linearis*, the oldest fossil then known. In 1851 he became Professor of Natural History in the University of Pennsylvania; in 1855, in Delaware College, acting also as Professor of Geology and Chemistry to the State Agricultural College, and subsequently became Professor of Comparative Philology in the first-named institution, when that chair was first established, and filled it continuously up to the time of his death.

Turning now to his record as an author, we find Professor Haldeman displayed amazing activity in a variety of branches. In his earlier years natural history was his passion, while in his later life linguistics and archæology occupied most of his attention.

The first work which I can find assigned to him was "Fresh Water Univalve Mollusca," published in 1840, 2 vols., 8vo, which is now out of print. This book is very scarce and it is difficult to obtain a copy, the last one that was sold bringing thirty dollars; in 1842 he published "Zoological Contributions;" in 1847 he issued a work on the "Genus Leptoxis," in French, while on a visit to Paris. It is part of the *Illustrations Conchologiques* of Dr. Chenu. In 1849 he issued his first philological work, entitled "Some Points in Linguistic Ethnology," dealing with English languages, and from that date he became recognized in the scientific world as one of the leading philologists.

In 1850 he published a work, "Zoology of the Invertebrate Animals;" in 1851, "Elements of Latin Pronunciation;" in 1855 he edited "Taylor's Statistics of Coal;" in 1856, a work on the "Relations of the English and Chinese Languages;" in 1864 he issued a work on the game of chess under the title of "Tours of a Chess Knight;" and in 1868, the "Rhymes of the Poets," under the *nom de plume* of "Felix Ago;" in 1871 he issued a work on "Affixes to English Words," and in 1877, his last work, entitled "Outlines of Etymology," was published.

The Professor leaves behind him a complete work on "Word Building," which is designed for the use of classes in Etymology, and which is ready for the printer; also a work on "English Prosody." He also leaves the manuscript of "Rat and River—a Tale of the Ohio," a mock heroic poem, and a poem of the same kind entitled, "Flight of the Fishes."

In addition to these works he has contributed probably one hundred and fifty papers on various scientific subjects, especially relating to Geology, Conchology, Entomology, Philology, and several branches of Zoology, which have been published in the Proceedings of the American Association for the Advancement of Science, the American Philosophical Society, American Philological Association, Academy of Natural Sciences, and many other learned societies of which he was a member. This Society is now publishing in their Transactions a monograph on "Contents of a Rock Retreat in Southeastern Pennsylvania," which is descriptive of the

Indian arrow heads and other relics found in the cave under Chickies rock. He was the first editor of the Pennsylvania "Farmers' Journal," a contributor to "Silliman's Journal," the "Iconographic Encyclopædia," the "Literary World," and Johnson's Cyclopædia.

Of the latter he was also an associate editor of the Comparative Philology and Linguistic department, and was the author of numerous articles in it. He also wrote two or three manuals of orthography, pronunciation and etymology, and his treatise on "Analytical Orthography," consisting of investigations into the philosophy of language, gained him, in 1858, the highest Trevelyan prize over eighteen competitors. He wrote the zoological portion of Trego's "Geography of Pennsylvania" (1843), and Rupp's "History of Lancaster County" (1844).

I have endeavored, without success, to prepare a complete list of these numerous papers, and must content myself with the above general references to them.

In conclusion, I wish to present an appreciative tribute to Prof. Haldeman's scientific attainments from the pen of his personal friend and our much esteemed member, Dr. John L. LeConte.

"Next to his valuable contributions in Philology, the most important work of Prof. Hâldeman was in the direction of descriptive Natural History. He was well versed in several branches of Zoology, and notably in Conchology and Entomology; in both studies he perceived latent possibilities of future philosophical development, which the then imperfect observations rendered impossible to do more than dimly outline. This quality is especially noticeable in remarks scattered through his monograph of Fresh Water Univalves of the United States, and in a memoir;* 'Enumeration of the recent fresh water Mollusca, which are common to North America and Europe, with observations on species and their distribution.'

"Without being a partisan, any more than myself, in the scientific squabble which then provoked much bitterness of expression between the contending factions, but which has since dwindled into comparative insignificance —the single or multiple origin of man—we held frequent conferences upon the subject. And in these friendly talks, I have heard him express himself freely on the impossibility of the results of the naturalist (now the biologist), being ever acceptable to the adherents of the scholastic school, 'For,' said he, 'if it be proved that organic forms are invariable during their continuance upon earth, then the different human races must be considered as having originated independently. If on the other hand, organic forms are plastic, under circumstances not yet understood, then the present species may have been developed from species which preceded them, and have not resulted from direct creative acts. Either horn of the dilemma is unsatisfactory to the metaphysical views prevalent.'

"While his contributions to the two branches of Zoology above mentioned have contributed to their advance in this country, what are especially to be admired are the zeal, the honesty of expression, and the unselfishness

* Boston Journal of Natural History, vol. iv, p. 468.

with which he did everything he believed to be right, or to be his duty as the occasion dictated.

"When in affluence, his contributions for the promotion of science were liberal. When in moderate circumstances, he pursued with equal industry such subjects in science as required small expenditure. But at all times he was an industrious and intelligent laborer, a warm and sympathetic friend, and a thorough hater of pretence and empiricism.

"Failing eyesight compelled him eventually to give up his studies in Zoology, and to devote his whole time to Linguistics, for which he had exhibited a growing taste for several previous years.

"The rare flexibility of his vocal organs gave him peculiar facility for analyzing and imitating the sounds in foreign languages, which he never lost any opportunity of hearing in his travels, both in this country and in Europe. In this matter his Natural History training in accurate observation, aided by remarkable perceptive qualities, gave him great advantage, and I am convinced that his analysis of the causes of change of sound in words, in passing from one language to another, will hereafter receive much more attention than they have heretofore done in this, the country of his birth, where such investigations are still in their infancy."

Stated Meeting, February 18, 1881.

Present, 12 members.

President, Mr. FRALEY, in the Chair.

A letter acknowledging Diploma was received from A. Akerman, dated Stockholm, Jan. 16, 1881.

A letter requesting missing numbers of the Proceedings was received from the Rhode Island Historical Society, February 14, 1881.

A letter respecting the third part of Transactions, Vol. XV, was received from E. A. Barber, 4008 Walnut street, Philadelphia, February 14, 1881.

Letters of acknowledgment were read.

Donations for the Library were received from the Mining Surveyors at Melbourne; the Zoologischer Anzeiger; the Academia dei Lincei; the Academy at Brussels; M. Delesse; the Revue Politique; London Nature; Journal of Forestry; Mr. T. S. Brown, of Montreal; Essex Institute; Poughkeepsie Society of Natural History; Mr. B. A. Hinsdale; Penna.

Magazine of History; Franklin Institute; Medical News; Mr. T. Meehan; Mr. H. Phillips, Jr.; Naturalist's Leisure Hour; State Board of Agriculture; Johns Hopkins University; Lighthouse Board; American Antiquarian Society; Wisconsin Historical Society; Robert Peter, M.D., and the Asiatic Society of Japan.

The death of the Rev. E. A. Washburn, D.D., at New York, February 2, 1881, aged 58 years, was announced by the Secretary.

The death of Auguste Mariette Pasha, at Cairo, Jan. 19 aged 60 years, was announced by Mr. Lesley, with a sketch of his career as an Egyptologist.

A communication was read, entitled "On the course of Fossil Botany," by Prof. M. B. Renouf, at Paris, by Leo Lesquereux.

A copy of the original photograph of the nebula in Orion was presented by Dr. H. Draper.

A communication was read, entitled "On certain old Almanacs published in Philadelphia between 1705 and 1744," by Henry Phillips, Jr.

The minutes of the last meeting of the Board of Officers and Members in Council were read. On motion the action of the Board in disposing of certain old newspapers by presentation to the Pennsylvania Historical Society was approved.

The following report of the Chairman of the Committee on the Michaux Legacy was read, as follows:

Report of the Chairman of the Committee on the Michaux Legacy:

Half of the income of the legacy for the last year was duly paid over by the Treasurer to the Treasurer of the Fairmount Park Commissioners, and has been duly applied to the cultivation and distribution of trees, partly in Park planting and partly to others.

The other half was not all spent because Professor Rothrock only delivered a half course of seven lectures in the Park, as he desired to go and went in the early summer to Strasburg to perfect himself in German, and to pursue his botanical studies under Professor De Barry. There was an increased attendance and interest in Dr. Rothrock's last spring's lectures.

Owing to but a dividend of 33 per cent. having been received for the Auxiliary Faculty by the University from Dr. Wood's estate, Dr. Roth-

rock will have but one-third his usual income from that chair. It is important that we keep him in Philadelphia. I therefore recommend an appropriation of $330 for a course of fourteen lectures in the Park.

The year 1880 was most abundant in tree seed, and they were gathered in quantities much greater than ever before and in more varieties. We have planted the Hardy Catalpa in large quantity and have the seed for planting this spring; also the seeds of the White Cedar, both very valuable for enduring wood.

ELI K. PRICE, *Chairman, &c.*

It was, on motion,

Resolved, That $330 be appropriated for the Michaux lectures.

On motion it was resolved that the whole subject of stereotyping and printing separately the publications of the Society for convenience in meeting such requests as that of Mr. Barber, in his letter of the 4th inst., be referred to the Committee on Publication, with the Treasurer, to report.

New nominations Nos. 928 to 931 were read.

And the meeting was adjourned.

On a Cours de Botanique Fossile by Prof. M. B. Renault. By Leo Lesquereux.

(Read before the American Philosophical Society, February 18, 1881.)

In this course of lectures given by Prof. Renault in the museum of natural history of Paris, the author gives very interesting details on the results he has obtained from anatomical analysis of silicified specimens of fossil plants. The volume recently published exposes the characters of a single group, the *Cicadeæ*, which the celebrated phyto-paleontologist has followed in all their subdivisions and modifications from the present age to the Devonian. These researches throw some new light on the nature or internal structure of some plants of the coal measures, especially the *Cordaites*, the *Sigillariæ* and *Stigmariæ*.

Prof. Renault divides the *Cicadeæ*, from the structure of the wood, trunks and leaves, in five groups or families, which from a difference in the essential characters of the wood he subdivides in two sections, A. B.

The plants are composed of vascular vessels forming two juxtaposed woody parts inversely increasing the one toward the centre (centripetal), the other toward the outside (centrifugal). This double increase is going on in both the leaves and the stems. To section A are referable the *Cicadeæ*, the *Zamiæ*, the *Cicadoxylæ*, and the *Cordaites*, to B the *Poroxylæ* and the *Sigillariæ* with the *Stigmariæ*.

The *Cordaites* and the *Sigillariæ* being now well known from American

specimens, are the only of these families which are interesting to the botanical paleontology of this country.

For the *Cordaites*, Prof. Renault has given very detailed anatomical descriptions and splendid illustrations of all the organs of these plants, as complete indeed as if they had been made from living vegetables. The development of the plants is followed from the fertilization of the ovule; for grains of pollen have been discovered, by vertically cutting the embryonic bodies, one already enclosed into the pollinic chamber, two of them still on their way downward in the pollinic tube.

The first of these grains is fully ripe, as recognized by the author, who has been enabled to see a difference in the mode of fertilization from the difference of size and structure of the grains of pollen which were as profusely disseminated around, at the Carboniferous epoch, as are those of the Conifers at our time. When found in a state of dissemination, the grains of pollen of the *Cordaites* are already a third larger than those still fixed to the anthers, and they appear then composed of an internal globule (entine). and of an outside envelope (extine). On the grains still placed in the pollinic tube, the fertilizing globule is more distinct, and more distinctly separated from the envelope, while the grain placed in the pollinic chamber is still larger, and its two parts more distinct. It seems therefore, according to the remarks of the author, that in their exit from the anthers, the pollinic grains are not fully ripe or prepared for the act of fecundation, and that they have need of a second process of evolution, while enclosed in the pollinic chamber, for a full separation of the cells and the completion of the fertilizing action. This process differs from what is remarked in the plants of the present time, by the fact only, that now the pollinic grain is already perfect, when it becomes detached from the anther, and is not surrounded by a membrane.

The wood of the trunks of *Cordaites* is composed of a thick pith or medullary cylinder, which is generally known under the name of *Artisia* or *Sternbergia*. The medullar cylinder very variable in thickness is obscurely costate lengthwise and transversely marked by close parallel furrows, sometimes anastomosing with each other. These furrows are formed, as seen from the anatomical analysis of silicified branches, by medullary transversal bands, which in the living plants, produced a division of the medial cylinder into as many empty excavations, each corresponding, by contraction of the surface, to an outside furrow.

The wood itself is formed in its inside part, or in contact with the medullary axis, of two zones; the inside of the first is composed of annulate and spiral trachids, its outside of radiate and reticulate ones separated by the medullary rays. The trachids of this last zone gradually pass, by the enlarging of the striæ of their walls, into punctate trachids, which constitute a second woody zone, which is of considerable thickness in large trunks, and always composed of trachids with areolate perforations, disposed in radiating striæ, and separated also by medullary rays. The areoles are in contact; by mutual compression they become hexagonal, and are pierced

in the centre by small pores or inclined fissures, which, by contraction or widening, become elliptical or round. In badly preserved or old specimens the pores occupy nearly the whole space of the areoles.

The characters of the wood of *Cordaites* as exposed above are much like those of the wood of some Conifers, and from this affinity, the fossil fragments of wood or trunks discovered in the Devonian and the Carboniferous, have been generally referred by authors to Conifers. *Dadoxylon* Endl., *Araucarites* Gœpp., *Pinites* Lind. and Hutt. are all referable to *Cordaites*. It is now well known that *Lomatophloios*, to which Corda referred the medullary cylinder of *Artisia*, has a far different kind of pith.

Considering especially the structure of the trunks of *Cordaites* and the character of the fructifications, Prof. Renault finds a relation between these plants and the *Cycadeæ*, from which they greatly differ, however, by their mode of growth and stature. The disposition of the flowers has some analogy with that of the *Taxineæ* or *Genetaceæ*.

The *Poroxyleæ* do not offer any remark applicable to what is known of fossil plants of this continent. They are represented by fossil trunks, of which three species are described by the author.

The *Sigillariæ* and the *Stigmariæ*, on the contrary, are of peculiar interest on account of the great abundance of their remains disseminated over and in the whole thickness of the American Coal measures, sometimes constituting whole strata of combustible mineral.

Prof. Renault finds, in the wood of *Sigillariæ*, medullary rays, an endogenous and an exogenous zone, and vasculur fascicles originating between the zones and constituting the strings of vessels entering and composing the leaves. These characters relate them to phanogamous gymnosperms.

From anatomical researches, Brongniart had come to the same conclusion, which is supported also by Saporta and Grand 'Eury. On the contrary Profs. Hooker, Williamson, Binney of England, who have pursued repeated observations and made numerous and very careful anatomical analysis of the wood of *Sigillariæ*, find in it the characters of Lycopodiaceous plants, and relate them to *Lepidodendron*.

The discordance of views may result, as supposed by Prof. Renault, from the difference of age of the plants from which were derived the specimens subjected to analysis. But the supposition is strongly contradicted by Prof. Williamson in a recently published paper, on the organization of the Fossil Plants of the Coal measures.* To follow the details of the discussion on this very interesting question it would be necessary to have the illustrations under the eyes.

We have no means of comparing the determination of the celebrated authors. All that I know and can see from American specimens of the outside characters of *Lepidodendron* and *Sigillaria* indicates a close typical relation of both genera, and therefore in the U. S. coal flora I have placed the genus *Sigillaria* in the *Lycopodiaceæ*.

Stigmaria necessarily follow *Sigillaria*; for remains of *Stigmaria* have

* Proc. of the Royal Soc., No. 205, 1880.

been found attached to trunks of *Sigillaria* as roots. From this fact Stigmaria plants have been generally admitted as true roots and are so in certain circumstances.

On this subject Prof. Williamson says, that *Stigmaria* belongs alike to *Lepidodendron* and to *Sigillaria* as root. I have never seen any positive relation of these two genera of plants, or never found any remains of *Stigmaria* in connection with those of Lepidodendron. Even in what seems to be a creeping state, or rooting like that of some Lycopods, the small intertexted stems of *Lepidodendron* exactly preserve the peculiar form of their leaf-scars and never have round areoles like *Stigmaria*.

What was known formerly of the structure of these plants by the anatomical analysis of phytopaleontologists is confirmed by the researches of Prof. Renault. However, from the mode of life of the *Stigmariæ* which in certain cases and for long periods of time appear to have had an independent vegetation, he supposes that these plants are of two kinds; some roots, others rhizomas.

In transversal section of *Stigmaria ficoides*, he has observed as obliquely traversing the woody cylinders two kinds of vascular fascicles, the first numerous, reaching to the outside, true vascular bundles of leaves; the others less numerous in the interior of the wood, which represent fascicles of roots. Hence in certain circumstances *Stigmaria* plants bear leaves; in others, fascicles of roots may be developed.

I have already at different times exposed my views on the variable nature of these plants according to their mode of vegetation. They have been more recently resumed in the description of the genus *Stigmaria*, Coal Flora of Pennsylvania and the United States, 1881, page 500, &c., and I think that they agree in all essential points with the opinion of the French author. *Stigmariæ* as stems (or rhizomas) have lived independently and for long periods of time floating at the surface of the swamps of the Carboniferous, or covering the soft mud, without producing any fructifications. In this case the stems, horizontal, rarely branching (dichotomous), preserve a uniform size, and bear also tubulous leaves only, more or less regularly disposed in spiral, no rootlets. Wide surfaces of rocks are covered with plants of this kind, and thick strata of clay are filled or composed of their remains, without any fragments or traces of *Sigillaria*. This vegetation may be called adventive. But in another case the germinating process may begin on sand or on a floating carpet of stems of *Stigmaria*, having become compact and solid enough to support trees. Then the growth of the plant from the production of a vertical bud proceeds upward and downward, and the basilar appendages, first obliquely inclined downward, become gradually more or less vertical as true roots and bear rootlets, often still mixed with leaves, as seen by their scars of different size and conformation. This kind of vegetation finds an analogy in that of a number of floating plants of our time: Mosses, Lycopods, etc.*

* Grand 'Eury has lately, in exploring the coal fields of Germany, recognized these two distinct modes of vegetation of the *Stigmaria*.

The work of Prof. Renault is closed by remarks on the geological distribution of the plants of the families which he has examined.

The *Cicadæ* appear in the Carboniferous by *Pterophyllum carbonarium* and persist through the more recent formations to our time.

The *Zamiæ* have also a carboniferous species *Naggerathia foliosa*, and a few others in the Jurassic.

The *Cycadoxylæ* are represented by fossil wood of the upper Carboniferous.

The *Cordaites*, the *Poroxylæ* and *Sigillariæ* are all Carboniferous and Devonian ; a few ascending to the base of the Permian.

Certain Almanacs Published in Philadelphia between 1705 *and* 1744.
By Henry Phillips, Jr.

(*Read before the American Philosophical Society, February* 18, 1881.)

In the library of our Society is a volume of Almanacs printed and published in Philadelphia, at various dates between 1705 and 1744.

They are remarkable specimens of the degree of perfection, or rather lack of perfection, to which the art of printing had attained in the Middle Colonies in those early days, beginning with extremely bad paper, blurred impressions and imperfect type, and exhibiting a progressive improvement towards the later dates, but nowhere showing, however, what now-a-days would be called a good piece of work.

The volume which is a duodecimo, consists of Jacob Taylor's Almanacs for 1705, 1706, 1709, 1711, 1712, 1719, 1720, 1723, 1727, 1738, 1740, 1741, 1743, 1744, and Titan Leed's Almanac for 1718.

As a curiosity I reproduce the title page of Taylor's Almanac for 1705, which will serve as a fair specimen of the manner in which publishers of that era were wont to attract the attention of the purchasing community.

An ALMANACK *for the year* 1705. | AN | EPHEMERIS | of the Motions and ASPECTS of the | PLANETS | and the *Eclipses* of the *Luminaries* for the *Year* | of *English* account 1705 | Fitted to the latitude of 40 Degrees North, and | the Longitude of 75 Degrees West of *London;* | serving *Pensilvania* and the Places adjacent. | By JACOB TAYLOR. | *Hermes Trismegistus.* Centiloq. Aphor. 88 | . *Saturn Passing out of one sign into another causes strange Appari* | *tions in the* Heavens *which the Arabians term* Asiub ; & *Cer* | *tain other signs of a fiery nature.* | To which is added by C. P. some remarks on D. L's abuses | to the *Quakers*, in his this *Years* two ALMANACKS. | Printed at *Philadelphia* by Tiberius Johnson. | .

This Almanac is a small volume of sixteen leaves, pages unnumbered and without signatures.

On the recto of the title page is a "Table of the KINGS of *England*, shewing the Years wherein They began to Reign ; the Years which they have Reigned, and the Years since they Reigned."

The second leaf is occupied by a piece of terrible poetry, most shockingly printed, in which is depicted the difficulty

"*To please all Humors suit all sorts of men,*"

and concluding with the lines,

"To them that shall presume that Risque to run,
To let us know how were imposed on,
Detraction, envy, slander shall accure (qy accrue?)
From that ill natured, vaunting, lying Artless Crue."

The last word is so badly printed as to be almost illegible.

The page following contains an explanation of the Almanac, and the characters and signs.

The next page sets forth the eclipses for 1705.

On the next page occurs "XI month JANUA. *Cæteris mensibus,*" below which is the usual calendar with weather predictions.

On the subsequent page is a table of the motions of the planets, beneath a heading "The Eleventh *Month* 1705," and followed by remarks on the Conjunction of Saturn and Mars set down for the month.

On the next page is "The XII Month FEBRUATIO *Romanorum,*" and beneath are the usual calculations and weather predictions. On the left hand pages the months continue, ending with DECEMBER, *Decimus Mensis.* On almost every right hand page there is a piece of poetry relating to the supposed influences of the starry bodies and their motions, as to the passage of the seasons. Under August, we find

"But *Leeds* exerts a Thumping Wit
Above all vulgar measure,
Moves Nature in a Jumping fit,
According to his pleasure;

Transcribing was the Art he us'd
'Twas all the skill he had,
But being of the same Accus'd
It almost made him M—D."

On the last three pages the author falls foul of Daniel Leeds, a rival Almanac maker, charging him with having stolen from Gadbury's Ephemeris and also from a little work by Jacob Taylor, entitled Eclipses of the Sun and Moon for twenty years. The attack is characterized by all the personalities and indecorum which were usual among our free spoken ancestors.

The first printing office in Pennsylvania was established about 1686, by William Bradford, and the earliest productions of this Press were Almanacs for the years 1686 and 1687. (Thomas, History of Printing, Vol. i, p. 209.)

The name of Jacob Taylor appears as that of a printer, who "was in town" in 1712, but Thomas states that he never met with anything that bore his imprint, and entertains doubts as to whether he was actually a printer. He says, "There was a Jacob Taylor, who for about thirty years annually calculated an Almanac, which was published in Philadel-

phia by Andrew Bradford; he was probably the same person; he died in 1746."

Thomas (Vol. i, p. 223) does not mention the existence of a printer named *Tiberius Johnson*, the person who printed this Almanac, but states that a certain *Renier Jansen* managed the press of William Bradford in Philadelphia from the time of his removal to New York until his son Andrew came of age.

Mr. John William Wallace, who has an especial knowledge of all things relating to early Pennsylvania printing, informs me that Tiberius Johnson was a son of Renier Jansen, whose name easily passed from and through the form of Jansen to Johnson, but he states that this Tiberius Johnson "so far as being an actual printer, or indeed a person having even a theoretical knowledge of typography * * * is a revelation" to him. That he never before heard of any imprint by him, and that the fact that he ever did make one has been generally unknown. This little volume, which bears his imprint, therefore appears to be unique.

It is therefore probable that Tiberius Johnson continued to nurse the business till Andrew took it. The Jacob Taylor Almanac for 1706 was "printed for the authór;" that of 1709, bears no imprint at all; 1711 and 1712, are "printed at Philadelphia." The Almanac of Jacob Taylor of 1719 bears the imprint of Andrew Bradford.

The Almanac issued by "Titan Leeds, Philomat" bears title "The *American* Almanac for the year * * * * * 1718 * * * Printed and Sold by Andrew Bradford at the sign of the Bible in Philadelphia."

It is likewise a small duodecimo of twelve leaves, lacking signatures and unnumbered.

On the *recto* of the title is an address to the "*Curteous Reader*" in which occurs the following passage;

"*Note*. That whereas my Preface, Last year gave Account that at least one Third of the Inhabitants of *West Jersey* were of the People called *Quakers*, but in my Copy I had written that there was not one third Quakers."

I Believe I may Venture,
To say this I do take,
For a wilfull mistake;
Of My Printer.'"

The usual figure of "The Anatomy of *Man's Body* as govern'd by the 12 Constellations" appears on the leaf following the title page, and is a most execrable work of art, shockingly engraved.

The astronomical calculations in the body of the Almanac are interspersed of pithy sayings of more or less point; such as, "Land winds are coldest, so sea winds are warmest," "He is sober who is never drunk with anything but wine," "The old woman would not seek her daughter in the oven if she had not been there herself," "Oft under honey sweet poison lurks," "March dust to be sold worth Ransom of Gold," "An evil crow an evil egg;" "Beware of a Smooth Devil;" "Scotch mist wets Englishmen to the Skin;" "So many planets joined together denote some Thun-

dring weather;" "Passion runs through all languages." "Proceed, but do justice;" "It is a bad Devil that does no good."

Above the calculations for each month is a piece of six lined poetry of moral and didactic nature.

In January it runs thus:

> Old Janers still begins the rouling Year,
> And all that's past no vows can e'er restore" * * *;

in December:

> "Death is a kalendar composed by Fate,
> Concerning all men, never out of Date." * * * * * *

It gives also a list of eclipses and the Date of holding "Supream Courts in *Pensilvania.*

At *Philadelphia* the tenth day of *April* and the 24 Day of *September.*

Courts of Quarter Sessions in *Pensilvania.* At *Philadelphia*, the first Monday in *March, June, September*, and *December*. * * *

Courts of Common Pleas are held: At *Philadelphia*, the first Wednesday after the Court of Quarter Sessions * *.

Then follow the terms of the *Supream* Courts and Courts of Common Pleas in New York, and the Supream Courts and Courts of Quarter Sessions in New Jersey, and at the end is a calendar of Court Days for Maryland.

Taylor's Almanac for 1719 was printed and sold by "Andrew Bradford in the Second Street near the great meeting House, in Philadelphia, 1719."

It is a small duodecimo of fifteen leaves, in signatures lettered respectively, A, B, C and D.

The compiler is honest enough to state, in the beginning, that "the Sentences on the Heads of the Monthly Pages are mostly borrowed."

Among the most noteworthy are the following:

"From the first Hour of the Day (or one in the morning inclusive) till six B good predominates, whence morning sleep becomes so sweet and pleasant, from thence to Noon, Choler, Afternoon, Phlegm, from the Beginning of the Night till Midnight, Melancholy."

"Near to St. Omer's in Flanders is a large Lake in which are divers floating Islands, most of them Inhabited, in one of them is a Church with a Monastery."

"In the Year 1276 the Countess of Heneberg Daughter to Florent the 4th Earl of Holland, had at one Birth 365 Children, all baptized by Don William suffragan Bishop of Treves, in two Brazen Dishes, in the Village of Loftleen."

Who can refuse credence to a fact so circumstantially set forth?

Taylor's Almanac for 1720 was issued by the same "Andrew Bradford at the sign of the Bible in Second Street."

At the head each of the twelve pages of the almanac on which the calculations for the months are set forth is a piece of poetry, and toward the end of the volume occurs a remarkable piece of rhyme, entitled A Cronology, setting forth various odd occurrences.

In Taylor's Almanac for 1728 we find the following poem:

"Full Forty years have now their changes made,
Since the foundation of this town was laid,
When Jove and Saturn were in Leo joined;
They saw the survey of the place design'd;
Swift were those planets, and the world will own
Swift was the progress of the rising town.
The Lion is an active Regal sign,
And Sol beheld the two superiors join,
A city built with such Propitious rays,
Will stand to see old Walls and happy days."

In Taylor's Almanac for 1737 occurs the following;

Take halfan Ounce of Rainbows fil'd to dust,
Three grains of Party-Papers true and just,
One grain of Satyrs, candid, just and fit,
Without Illnature, cant or dev'lsh wit;
Mix these with Art to make the sov'reign Pills,
That cured Train of Epidemic Ills.

In the MSS is written in an old hand on the page for December, "The 7th near 11 at night a shock of an earthquake generally felt through the Province but no damage as I've heard of."

In Taylor's Almanac for 1738 occurs the following poetical description of the Province of Pennsylvania:

"In this new world, so lately here begun,
A thousand miles our King's dominions run;
About the centre lies well known to fame
The Silvan shade that bears the Land Lord's name.
A fruitful soil with gifts of nature blest,
Improved by culture swifter than the rest.
Like Palestine a land of good repute,
For wheat and barley, honey, milk and fruit.
Here not in vain the Master's skilful hand
Manures the glebe, and cultivates the land:
The ground producing ev'ry sort of grain,
Pomarious profit, and the hortensian gain.
Except not Rice, some by experience know,
That useful grain will here in plenty grow.
In wool and flax the Province will be made
Too rich in time to call for foreign aid.
And useful Hemp, its service to declare,
Four Clerks would fail, Accountants all despair.
Its magic-virtue in a skillful hand,
Preserves the substance of a prudent land;
Who can at large its various uses tell?
What Clouds of Canvass on the Ocean swell!
Th' extensive use of Cordage to declare,
The Labour might with *Pliny's* works compare.
I only touch the profits of the field;
And leave the Task for stronger hands to wield.
And now my wild unbounded fancy roves
In that vast region of the trees and groves;
But, lest therein, I scarce pretend to know
What sorts of Oak in this great forest grow;
As many kinds, some say, as metals ly
Beneath the ground, or Planets in the sky,

The chestnut tree for various uses good,
Though soft and tender yet a lasting wood;
Where numerous Chestnuts shade the fertile ground,
Good fence with ease may spacious fields surround.
As for the nuts, they may with acorns join,
A noble mast for saginating swine.
The cedar, spruce and cypress here are seen,
The pine and laurel, these are very green,
The ash, the beech, the maple chiefly grow
By streams of waters and in vallies low.
The sable walnut, and the locust strong
Grow here in groves, and wrestle in the throng.
The poplar's lofty head the clouds invades,
The spreading boughs defusing lovely shades.
The fir-tree may the lofty mountain grace
And pines in gardens man for beauty place;
But, while the verdure leaves, in none you see,
A nobler prospect than the popler tree.
Here liquid Sugar drops from wounded trees,
And aspen groves invite the gentle breeze.
And now behold the lofty hills arise,
That bear the arches of th' impending skies,
Observe the rivals, and decide between
Celestial azure and the mountan green.
Behold the groves, consider well the skie,
And say wherein the greater beauties ly.
Which most the Mind with joy and wonder fills,
The sky-blue curtain, or the verdant hills.
When Israel's sons were led by Moses' hand,
Who told the glories of the holy land,
Melodious Themes the sacred Leader sings,
Of hills and vallies, fountains, brooks and springs.
What grov'ling Soul with patience can sustain
The dull flat prospect of a constant plain;
And ne'er reflect what precious treasure fills
These *ancient mountains and the lasting hills.* Deut. 33. 15
No dreams of gold or views of argent veins
T' involve the land in war, the poor in chains.
I sing the treasure now before your Eyes,
The growing profit and the solid prize.
The well-know metal of a gen'ral use,
In copious stores the bounteous hills produce:
The neighboring groves, the trees, as plenty grow,
To melt the ore and make the metal flow.
The world's last age may terminate the store
Of trees above, and under ground the oar.
To know what profit may from thence be made
Ask not the stars, nor seek a Python's aid;
As when you see the rising Tyde begin,
And from the Ocean floods come rolling in,
It moves no wonder, gives you no surprise,
The swelling water will by nature rise.
So when a hundred kilns and forges glow,
A thousand streams of melted metal flow,
Not the possessors of the Mines alone
Will hoard the gain and make it all their own.
The trade and profit, circling like the blood,
Will then become a universal good.

This most peculiar blessing rarely fails,
The happy land adorned with hills and vales,
The crystal springs that wash the mountain's side,
Start from the hills and through the valleys glide,
Collect their force from single drops begun,
Unite their streams, enlarging as they run;
From brook to brook discharge the liquid store,
Till ample Rivers in procession roar.
Where these abound who can the blessing tell
Which all enjoy and few consider well.
Upon the horrid fields of driving sand,
Betwixt *Numedia* and the Negro's land,
A merchant's tomb his monument remains
Who dy'd of thirst upon the scorching plain:
A greedy carrier, fond of sacred gold,
A draught of water to the merchant sold,
Ten thousand Ducats was the price it cost,
So dear he paid his dearer life he lost.
Who can behold the springs and purling rills
In sweet Meanders gliding down the hills,
And not remember these unhappy plains,
Where horror dwells and death forever reigns?

In June is written in an old hand "y^e^ Governour arrived y^e^ 1^st^ day."

In August of this year;

If needless, things we laid aside,
A woman destitute of Pride,
Bohea *and* Green *would scarcely steer*
Twelve thousand miles to find us here.

Taylor for 1741 is filled with quotations from Paradise Lost.

Taylor's Almanac for 1743 was "printed and sold by ISAIAH WARNER almost opposite to CHARLES BROCKDEN'S, in *Chesnut-Street;*" and contains

"The *Indian Prophecy.*

"An Indian of this Province looking at the great Comet *Anno* 1680, being asked what he thought was the Meaning of that prodigious Appearance, his answer was, "*It signifies that we Indians shall melt away and this country be inhabited by another sort of People.*" This Prediction the *Indian* delivered very grave and positive, to a *Dutchman* of good Reputation, living there and many Years since near *Chester*, on *Delaware*, who related the same punctually to an *Englishman*, now living, whose Veracity, I think, is never questioned." The chain of evidence here is certainly very remarkable, but cannot be called conclusive. In the same Almanac at the end of an article on Politics occurs these words: "from us to the river *St. Laurence*, we know the space too well. I could wish that his most Christian Majesty had, in lieu of that, a Country ten times better, and a thousand times the distance."

Taylor's Almanac for 1744, was "Printed and sold by I. WARNER and C. BRADFORD at the sign of the BIBLE in *Front-Street.*"

The whole collection, filled with quaint and curious matter of which the foregoing is a fair specimen, is well worthy of attention as an example of early printing in Pennsylvania. The orthography is extremely unsettled, and the grammar equally uncertain.

Stated Meeting, March 4, 1881.

Present, 13 members.

President, Mr. FRALEY, in the Chair.

Mr. Ames and Dr. Wurtz, new members, were introduced to the presiding officer and took their seats.

A letter acknowledging receipt of Diploma was received from Prof. James Geikie, dated Perth, Scotland, July 14, 1881.

The thanks of the American Institute of Mining Engineers for the use of the Hall was received.

The request for correspondence of the Vermont Historical Society was read and agreed to.

Letters of envoy and acknowledgment were read.

Donations for the Library were received from the Academies at St. Petersburgh, Berlin, Vienna, Rome and Dublin; the Societies at Königsburg Dresden, Halle and Giessen; the Geological Society at Berlin; the Geological International Commission, Lausanne; the Würtemberg Land History Society at Stutgart; the Zoologischer Anzeiger; the Zoölogical Garden at Frankford; the Revista Euskara at Pamplona; the the Bureau of Statistics at Brussels; the Paris Geographical Society, Polytechnic School and Political Review; the Geographical Commercial Society at Bordeaux; the Institute for Earth Magnetism at Vienna; the Royal Society, London; the Greenwich Observatory, the Adelaide Observatory, the Meteorological Society, the Royal Geographical Society, the Geological Society, the Linnean Society, the Zoölogical Society, the Royal Asiatic Society and the Society of Arts, London; the Radcliff Observatory at Oxford; R. Cornwall Polytechnic Society; the Philosophical and Literary Society, Leeds; and Mr. James Henry of Dublin.

Mr. Lesley read a paper entitled "Notes on the meaning of the word *Hebrews*, and on Egyptian names of Hebrew kings."

Pending nominations Nos. 927 to 931, and new nomination No. 932 were read.

And the meeting was adjourned.

Stated Meeting, March 18, 1881.

Present, 18 members.

President, Mr. FRALEY, in the Chair.

The resignation of Dr. C. J. Stillé, dated February 17, 1881, was received and accepted.

A letter of thanks for the gift of a copy in oil of the portrait of Michaux, was received from the Commissioners of the Fairmount Park, dated March 12, 1881.

A letter requesting the deposit of historical documents in the hall of the Historical Society of Pennsylvania was referred to the Library Committee, the Librarian and Dr. Horn, to report.

Letters of acknowledgment were received from the London Statistical Society (106 and List); the Society of Antiquaries (106); New Bedford Library (107); and the Cincinnati Observatory (107).

Letters of envoy were received from the Geological Survey of India, July, 1880; the Austrian Academy, Aug. 25; Prof. W. F. Hewitt, Ithaca, March 16; and the U. S. Coast and Geodetic Survey, March 15, 1881.

Donations for the Library were received from the Geological Survey of India; the Academies at Turin, Rome, Modena, Copenhagen and Brussels; the Turin Observatory; the Institutes at Milan and Venice; Prof. Gio. Capellini, Bologna; the Geological Commission at Florence; the Geographical Societies at Paris and Bordeaux; the Flora Batava; the British Topographical Society; London Nature; the American Statistical Association; Mr. Samuel Scudder; Museum C. Z. Cambridge; New Bedford Library; Dr. Geo. W. Hawes; American Journal A. and S.; New York Academy of Sciences, State Museum, and Prof. Jas. Hall; Prof. W. T. Hewett, Ithaca; Buffalo Nat. Hist. Society; Trenton Experimental Station; Franklin Institute, Num. and Antiq. Society, Journal of Pharmacy, Medical News, Mr. Reuben Haines and Mr. H. Phillips, Jr., Philadel-

phia; Gov. Hoyt; U. S. N. Observatory; U. S. C. and G. Survey; Mr. Jed. Hotchkiss, Staunton, Va.; San Franc. Mer. Association; Min. de Fom. and M. M. Barcena, Mexico.

The death of Dr. John J. Bigsby was announced by the Secretary, with remarks on his early connection with geological exploration in America.

The death of Prof. John Johnston, at Middlebury, Connecticut, in 1879, was reported.

A memoir On the Preglacial drainage of Lake Erie and the other great lakes, by Dr. J. W. Spencer, was read and illustrated by the Secretary.

A paper on "A Geological Section at St. Mary's, in Elk County, Pa.," was read by Mr. Ashburner.

Pending nominations, Nos. 927 to 932, and new nomination, No. 933, were read.

And the meeting was adjourned.

Discovery of the Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario; with Notes on the Origin of our Lower Great Lakes.

By J. W. Spencer, B. A. Sc., Ph. D., F. G. S., King's College, Windsor, N. S.

(*Read before the American Philosophical Society, March* 18, 1881.)

Summary.

The object of this paper is to bring before the scientific world the following observations, bearing on the Preglacial Drainage and origin of our Great Lake Basins:

1. The Niagara escarpment, after skirting the southern shores of Lake Ontario, bends at nearly right angles in the neighborhood of Hamilton, at the western end of the lake; thence the trend is northward to Lake Huron. At the extreme western end of the lake this escarpment (at a height of about 500 feet) encloses a valley gradually narrowing to four miles, at the meridian of the western part of the city of Hamilton, where it suddenly closes to a width of a little more than two miles, to form the eastern end of the Dundas valley (proper). This valley has its two sides nearly parallel, and is bounded by vertical escarpments, which are capped with a great thickness of Niagara limestone, but having the lower beds of the slopes composed of Medina shales. On its northern side the escarpment extends for six miles to Copetown; but westward of this village it is covered with

drift, but it is not absent. On its southern side the steep slopes extend for less than four miles to Ancaster, where they abruptly end in a great deposit of drift, which there fills the valley to near its summit, but which is partly re-excavated by the modern streams, forming gorges from two to three hundred feet deep. To the north-eastward of Ancaster these gorges are cut down through the drift to nearly the present lake level.

Westward of Ancaster, a basin occupying a hundred square miles, where the drift is found to a great depth, forms the western extension of the Dundas valley. With the north-western and western portions of this drift-filled area the upper portion of the Grand river and Neith's creek were formerly connected. The Grand river, from Brantford to Seneca, runs near the southern boundary of this basin, then it enters its old valley, which extends from Seneca to Cayuga, with a breadth of two miles, and a depth, in modern times, of seventy-five feet, having its bed but a few feet above the surface of Lake Erie. Near Cayuga, the deepest portion of the river-bed is below the level of Lake Erie.

2. The Dundas valley and the country westward form a portion of a great *river valley*, filled with drift. Along and near its present southern margin this drift has been penetrated to 227 feet below the surface of Lake Ontario, thus producing a *cañon* with a lateral depth of 743 feet, but with a computed depth, in the middle of its course, of about 1000 feet.

3. The Grand river, at four miles south of Galt, has, since the Ice Age, left its ancient bed, which formerly connected with that of the Dundas valley, as did also Neith's creek, at Paris.

4. Lake Erie emptied by a buried channel a few miles westward of the present mouth of the Grand river, and flowed for half a dozen miles to near Cayuga, where it entered the present valley, and continued this channel (reversed) to a place at a short distance westward of Seneca, whence it turned into the basin referred to above, receiving the upper waters of the Grand river and Neith's creek as tributaries, and then emptied into Lake Ontario by the Dundas valley. This channel was also deep enough to drain Lake Huron.

5. Throughout nearly the whole length of Lake Ontario, and at no great distance from its southern shore, there is a submerged escarpment (of the Hudson River Formation) which, in magnitude, is comparable with the Niagara escarpment itself, now skirting the lake shore. It was along the foot of this escarpment that the river from the Dundas valley flowed (giving it the present form) to eastward of or near to Oswego, receiving many streams along its course.

6. The western portion of the Lake Erie basin, the south-western counties of Ontario, and the southern portion of the basin of Lake Huron formed one Preglacial plane, which is now covered with drift or water (or with both) to a depth varying from fifty to one hundred feet, excepting in channels where the filling by drift is very great. A deep channel draining Lake Huron extended through this region, leaving the present lake near the Au Sable river, and entering the Erie basin between Port Stanley and

Vienna, at a depth near its known margin of 200 feet, but at a probable depth in the centre sufficiently great to drain Lake Huron.

6. The Preglacial valleys (now buried) of Ohio and Pennsylvania—for example; the Cuyahoga, Mahoning (reversed), and Allegheny (deflected), formed tributaries to the great river flowing through the Erie basin and the Dundas valley.

7. The bays and inlets north of Lake Huron are true fiords in character, and are of aqueous origin.

8. The Great Lakes owe their existence to sub-aërial and fluviatile agencies, being old valleys of erosion of great age, but with their outlets closed by drift. Glaciers did not excavate the lakes and had no important action in bringing about the present topography of the basins.

9. The old outlet of the Niagara river, by the valley of St. David's, was probably an interglacial channel.

I. Introduction.

Whilst residing in Hamilton, Ontario (1877–80), a portion of my time was devoted to studying the geology of the neighborhood. At first it began in connection with Lieut. Col. Grant, H. P., Sixteenth Regiment, and some other gentlemen, in making collections of fossils; as this locality is one of the best for obtaining Niagara Fossils (and also those of the Hudson River Formation from the drift pebbles in the beaches) in Canada. In 1874, the present writer published in the *Canadian Naturalist* a sketch of the local geology. In 1878, he laid the plan of collecting the information necessary for preparing an exhaustive paper on the Geology of the region about the Western End of Lake Ontario. When systematic work was commenced, the information gained required so much time for its study that it has long delayed the publication. A large number of new species of Niagara fossils (twenty-nine of the Graptolite family alone) were obtained. The present state of the work is, that a paper on the Palæozoic Geology, and another on the Palæontology, containing descriptions of many new fossil species, are ready for publication. A third portion, on the Surface Geology, is under way; and the investigations on this subject have, step by step, carried the writer outside of his original field,—having assumed an importance never anticipated; and have resulted in this advance notice of a few of the most striking facts concerning the origin of our great lakes. The completion of the work will be further delayed until opportunity will have been afforded to study some questionable points, especially such as relate to the drift deposits of the region, and others having a broader bearing on the physical geography of the lake regions in Preglacial times.

In the present paper, all discussion relating to the vexed glacial hypothesis is scrupulously avoided, except those questions bearing on a true explanation of the origin of our great lakes.

In the study of the surface geology, the first great question that presented itself was, "What is the origin of my native valley, Dundas?" The

possibility of Lake Erie flowing down through the Dundas valley (though it suggested itself) did not seem probable, owing to the high lands between the two great lakes. However, in the *Canadian Naturalist*, 1874, I referred to it as having been produced by a "mighty river." This was like one of those gratuitous hypotheses that are common, now-a-days, for attributing to a continental ice sheet most of the causes of the present physical features of the continent, which do not readily explain themselves. Subsequently, Mr. George J. Hinde refers to it as having been scooped out by a glacier. This assertion will be found in the sequel to be a perfectly untenable hypothesis. Certainly, the origin of the valley was obscure, yet it showed that the excavation of a *cañon* of such magnitude required a proportionately great agent; and no present stream would account for even a small portion of the excavation. However, in this paper it will be seen that its existence was unquestionably occasioned by the action of a mighty river, as originally suggested. This outlet of Lake Erie also perfectly accords with, and accounts for the preglacial drainage of Pennsylvania, as made known at the close of last year by Mr. Carll; of the Geological Survey of that State.

II. Topography of the Region about the Western End of Lake Ontario.

The Niagara Escarpment.—This range of hills commences its course in Central New York, and extends westward, at no great distance south of Lake Ontario. It enters Canada at Queenston Heights, and thence its trend is to the western end of the lake, where, near Hamilton, it turns northward and extends to Cabot's head and Maintoulin island. Everywhere in Canada, south of Lake Ontario, it has an abrupt fall looking towards the northward; but at Thorold and other places to the eastward its bow is more broken than at Grimsby, and westward. At Hamilton, the brow of the escarpment varies from 388 to 396 feet above Lake Ontario.* About five miles east of Hamilton, the escarpment makes an abrupt bend enclosing a triangular valley, down which Rosseaux creek, and other streams now flow. This valley is about two miles wide at its mouth, and has a length of about the same distance.

About five miles westward of Hamilton, the Niagara escarpment becomes covered with the drift deposits of a broken country, or rather ends abruptly in the drift of the region. Above the range, the country gradually rises to the divide between Lake Ontario and the Grand river, or Lake Erie, without any conspicuous features. South-eastward of Hamilton, at a point about five miles from the brow of the escarpment, where the Ham-

* Prof. Dana places the mean level of Lake Ontario at 233.5 feet above ocean-level; the Canadian Geological Survey, at 232 feet; the New York Central Railroad, at 240.84; the Geological Survey of Pennsylvania, takes 573 feet as the mean of the results of determining the level of Lake Erie; the Welland canal levels show Lake Erie as being 326.75 feet higher than Lake Ontario; and the Hamilton and North Western Railway a difference of 328 feet, both of these last routes being short lines with direct courses. Therefore the height of Lake Ontario should be about 245 feet above the sea.

ilton and North Western Railway reaches the summit, the altitude above Lake Ontario is 493 feet. At Carpenter's quarry, two miles southward of the "mountain" brow, at the head of James street, the altitude reaches 485 feet; and near Ancaster the summit is 510 feet above Lake Ontario. From eastward of Grimsby (for twenty miles) to near Ancaster, the escarpment presents an abrupt face from 150 to 250 feet below the summit (having a moderate amount of *talus* at the base), thence it extends by a more or less steep series of slopes to the plane, which gradually inclines (sometimes by a succession of terraces), to the lake margin.

On the northern side of the town of Dundas, the abrupt face of the escarpment looks southward, and extends four or five miles westward, until the exposure becomes covered by the drift deposits near Copetown station, similar to the termination at Ancaster on the south side of the Dundas valley, but not by an abrupt ending as at the latter locality. About two miles east of the G. W. Railway station, at Dundas, the trend of the range bends more to the northward, and from this point there is a marked difference in the configuration of the country below the summit. The range, after extending beyond Waterdown, turns still more to the northward and passes near Milton, and Limehouse station (on the G. T. Railway), and thence extends to Georgian bay. The height of Copetown above the lake is 502 feet. On the west side of Glen Spencer it is 409 feet, and eastward of the same gorge the highest point is 520 feet (Niagara limestone coming within four feet of the surface). At Waterdown the altitude is over 500 feet (?) and at Limehouse the brow of the range (though only the lower beds of the Niagara limestones occur) is 810 feet. The features of the surface of the country above the highlands north of Dundas are much more varied than south of the Dundas valley. As the trend of the escarpment turns northward around the end of the lake, the face of the slope looks towards the eastward. But the country does not present the steep declivities as exhibited along the southern side of Lake Ontario; for the vertical face is usually less than 100 feet, and the country between it and the water has a more uniform pitch.

Basin of Lake Ontario. As is well known, Lake Ontario consists of a broad, shallow (considering its size) basin, excavated on the southern margin out of the Medina shales, and having its southern shores from one to several miles from the foot of the Niagara escarpment. The Medina shales form the western margin (where not covered with drift) to a point near Oakville. From this town to a point some distance eastward of Toronto, the hard rocks are made up of the different beds of Hudson River Epoch; while the soft Utica shales occupies the middle portion, and the Trenton limestones the portion of the Province towards the eastern end of the lake.

The country at the western end of the lake consists of slopes gently rising to the foot of the Niagara escarpment, noticed before. Sometimes this elevation is by terraces, and again by inclines so gentle, as between the foot of the escarpment at Limehouse (on the G. T. Railway) and the lake, where

the difference of altitude above the water is more than 700 feet, without any very conspicuous features.

At the western end of the lake, the two shores converge at an acute angle. At about five miles from the apex of this angle is the low Burlington beach, thrown across the waters in a slightly curved line, which forms the western end of the open lake. Burlington lake, thus formed, is connected with the open lake by a canal of the same name, made where there was a former shallow opening between the waters within and without the beach. This beach is made up of sand and pebbles (mostly of Hudson River Age), and is more than four miles long, but nowhere is it half a mile wide.

No mean depth of Lake Ontario can be fairly stated. For geological purposes it has no mean depth, because it is simply a long channel with the adjacent low lands covered by back-water.

West of the meridian of the Niagara river the lake is evidently filled with more silt then eastward, as we find that the bottom slopes more gradually towards the centre, where the mean depth (increasing from the westward) of the channel may be fairly placed at 400 feet below the present surface of the waters. In this section of the lake, the average slope from both shores may be stated at 30 feet in a mile. At a short distance east of the 78th meridian, the character of the late bottom changes in a most conspicuous manner. Here we find a deeper channel which extends for more than ninety miles, having an average depth of about 90 fathoms or 540 feet, with, in some places, a trough of about 600 feet depth, generally near the southern margin of the 90-fathom channel. Here and there is a deeper sounding—the deepest being 123 fathoms or 738 feet. The long channel, surrounded by the 90-fathom contour line, is situated at a mean distance of not less than twenty miles from the Canadian shore, whilst its southern side approaches in some places to within six miles of the American shore, with which it is parallel. This 90-fathom channel varies from three to twelve miles in width. Its broadest and deepest portion is south of the Canadian peninsula of Prince Edwards' County.

The mean slope of the lake bottom, from the Canadian shore to this deep channel just pointed out, may be placed at less than twenty-five feet in a mile, with variations from twenty to thirty feet in that distance. The mean slope from the New York shore line to the 90-fathom channel may be placed at sixty feet in a mile, but varying generally from fifty to ninety feet. On examination we find that the greater portion of this slope belongs to a belt which descends much more rapidly than the off-shore depression.

That the southern side of Lake Ontario has a submerged series of escarpments or one moderately steep and of great dimensions, is manifest when we come to study the soundings. In fact, if the bed of Lake Ontario were lifted out of the water, this submerged escarpment would be more conspicuous than the greater portion of the present one, known by the name of the Niagara. In many places the descent from the table-land above the Niagara escarpment is no more precipitous than the slopes of the sub-

merged Cambro-Silurian (Hudson River, in part, if not throughout the entire length) rocks, with its sloping summit, in part crowned by a gently sloping surface of Medina shales. Nearly north of the mouth of the Genesee river we find that within a single mile the soundings vary from forty-three to seventy-eight fathoms (between contour lines). This gives a sudden descent in one mile of 210 feet. As the soundings are not taken continuously to show to the contrary, most of the change of levels may be within a few hundred yards.

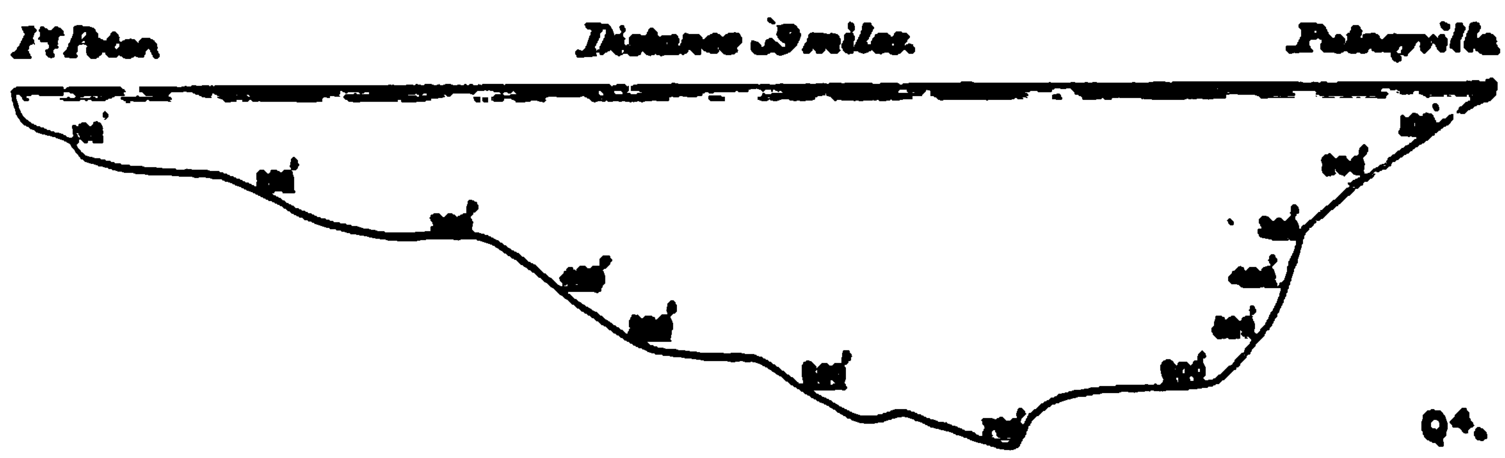
In the region of these soundings the deepest water outside of the 78-fathom line is 84 fathoms, while from the shore to the 43-fathom sounding the least distance is four and a half miles, thus giving the greatest mean slope of the lake bottom at sixty feet in a mile, before the escarpment is reached.

An excellent series of soundings can be studied in a line nearly northward from Pultneyville, N. Y.:

Distance from Pultneyville		Depth of Sounding.	Slope from previous Sounding.
0.5 miles.		42 feet.	
1.0 "		72 "	60 feet per mile.
1.75 "		126 "	72 " "
4.125 "		246 "	50 " "
5.0 "	Face of the escarpment.	372 "	144 " "
6.0 "		582 "	210 " "
7.0 "		624 "	42 " "
10.0 "		642 "	6 " "
12.0 "		738 "	48 " "

Fig. 1.

Section of Lake Ontario from Point Peter Light, Ontario, to Pulneyville, N.Y.



From this table it will be seen that in a distance of less than two miles the slope of the escarpment is the difference between 582 and 246 feet, or 336 feet as actually recorded. At Hamilton, the Niagara escarpment is only 388 feet above the lake, which is two miles distant, whilst the present slope at Thorold is spread over nearly twice that distance. That this escarpment is not local is easily seen. For a distance of over forty miles, from near Oswego westward, it plunges down 300 feet or more in a breadth varying from less than two to three miles. Eastward and westward of this portion of the lake this submerged escarpment can be traced for nearly

one hundred miles, but with the portion deeper than the 70-fathom contour having more gradual soundings, as the base of the hills either originally had a more gradual slope, or the lake in its western extension has subsequently been filled with more silt.

Although we have not soundings made very close together, yet the admirable work of the United States Lake Survey is more than sufficient to prove the existing of a continuous escarpment that has an important bearing on the Preglacial geography of the region, and on the explanation of the origin of the Great Lakes themselves.

The soundings do not show a conspicuous escarpment after passing westward of the meridian of Niagara river, partly on account of the sediments filling this portion of the lake, and partly because the lake in all probability never had its channel excavated to so great a depth as farther eastward.

Attention must be called to the fact that the depth of the Niagara river is 12 fathoms near its mouth, but that the lake around the outlet of the river has not a depth exceeding four fathoms with a rocky bottom.

Another escarpment at the level of Lake Ontario, now buried, was discovered by the engineers of the enlargement of the Welland canal, according to Prof. Claypole (Can. Nat. Vol. ix, No. 4). When constructing, No. 1 lock, at Port Dalhousie, it was found that at its northern end, there was an absence of hard rock which formed the foundation of its southern end. Rods more than 40 feet long were pushed into the slimy earth without meeting any hard rock bottom. This discovery will be noticed in the sequel. *

Basin of Lake Erie. The exceedingly shallow basin of Lake Erie has its bottom as near a level plane as any terrestrial tract could be. Its mean depth, or even maxima and minima depths from its western end for more than 150 miles, scarcely varies from 12 or 13 fathoms for the greater portion of its width. The eastern 20 miles has also a bed no deeper than the western portion. Between these two portions of the lake, the hydrography shows an area with twice this depth (the deepest sounding being 35 fathoms). This deepest portion skirts Long Point (the extremity, a modern peninsula of lacustrine origin), and has a somewhat transverse course. An area of less than 40 miles long has a depth of more than 20 fathoms. The deeper channel seems to turn around Long Point, and take a course towards Haldemand county, in our Canadian Province, somewhere west of Maitland. The outlet of the lake, in the direction of the Niagara river, has a rocky bottom (Coniferous limestone).

The study of this lake at first appears less practicable than that of Ontario, but, when its former outlet and its tributary rivers are described, the writer trusts that he will have made some observations, that may help to clear the darkness that hangs about the history of our interesting lake region, before the advent of the Ice Age.

The Dundas Valley and adjacent Cañons. We may consider that the

* See Report of Chief Engineer of Canadian Canals, 1880.

Dundas valley begins at the "bluff" east of the Hamilton reservoir, and extends westward, including the location of the city of Hamilton and the Burlington bay, at least its western portion. With this definition, the width at the Burlington heights (an old lake terrace 108 feet above present level of the water) would be less than five miles. At a mile and half westward of the heights, the valley suddenly becomes narrowed (equally on both sides of its axis of direction, by the Niagara escarpment making two equal concave bends, on each side of the valley, whence the straight upper portion extends, the whole resembling the outline of a thistle and its stem), from which place it extends six miles westward to Copetown, on the northern side; and three and a half to Ancaster, on its southern side. The breadth between the limestone walls of this valley varies somewhat from two to two and a half miles. The summit angles of the limestone walls on both sides are decidedly sharp.

Dundas town is situated in this valley, its centre having a height of about 70 feet above Lake Ontario, but its sides rise in terraces or abrupt hills; and on ascending the valley, we find that between the escarpments are great ranges of parallel hills separated by deep gorges or glens, excavated in the drift by modern streams. This rugged character continues until the summit of the Post Pliocene ridges have a height equal to that of the escarpment. As the gorges ascend towards the westward, they become smaller, until at some distance south-west of Copetown and Ancaster, the divide of the present system of drainage is reached. Some of these streams have cut through the drift, so that they have only an altitude above the lake (which is seven miles distant) of 240 feet, while the tops of the ridges immediately in the neighborhood are not much less than 400 feet high, though they themselves have been removed to a depth of about another hundred feet, for the drift has filled the upper portion of the valley to the height of 500 feet above Lake Ontario. Even to the very sources of the streams, the country resembles the rivers of our great North Western Territories (or those of the Western States), cutting their way through a deep drift at high altitudes, which is not underlaid by harder rocks, showing deep valleys rapidly increasing in size and depth, as they are cleaning out the soft material, and hurrying down to lower levels—a strong contrast to the features in most other portions of our Province.

On the south side of the Dundas valley, a few unimportant streams, mostly dry in summer, have worn back the limestone escarpment, over which they flow, to distances varying from a few yards to a few hundred, making glens at whose head in spring time some picturesque cascades can be seen. At Mount Albion, six miles east of Hamilton, there are two of these larger gorges, whose waters, after passing over picturesque falls, 70 feet high, and through glens several hundred yards in length, empty into the triangular valley noticed before. On the north side of the Dundas valley, besides small gorges with their streams comparable to those on the south side, there are several of much larger dimensions; for example, that at Waterdown, six miles north of Hamilton. Still larger is Glen Spencer which has a *cañon* half

a mile long, 300 feet deep and between 200 and 300 yards wide at its mouth. At the head of this is Spencer Falls, 135 feet high, and joining it laterally there is another *cañon*, with a considerable stream flowing from Webster's Falls, which, however, is of less height than the other. The waters feeding their streams come from northward of the escarpment, and belong to a system of drainage different from those streams which flow down through the drift of the Dundas valley, and are of much greater length. At the foot of Spencer Falls, the waters strike the upper portion of the Clinton shaly beds. The Falls now are two feet deeper than twenty years ago. Yet the stream is small, and makes a pond below in the soft shales. But this difference in height does not represent the rate of wearing or recession of the precipice. That the stream is much smaller than formerly is plainly to be seen, for at present it has cut a narrow channel, from ten to fifteen yards in width, above the falls, and from four to six feet deep, on one side of the more ancient valley, which is about 50 yards wide and 30 feet deep, excavated in the Niagara dolomites.

The surfaces of the escarpment in both sides of Glens Spencer and Webster present a peculiar aspect. That on the north-eastern side has a maximum height of 520 feet above the lake. On the same side, a section made longitudinally shows several broad shallow glens nearly a hundred feet deep crossing it and entering Glen Spencer. The surface of the rocks is glaciated, but not parallel with the direction of the channels. On the south-western side of the same *cañon*, we find that a portion of the thin beds of Upper Niagara limestone have been removed. This absence is not general, for it soon regains its average height of about 500 feet.

Dundas Marsh. The eastern end of the Dundas valley contains a large swamp, nearly three miles long, with a breadth of about three-fourths of a mile, known in the early settlement of the country by the name of Coote's Paradise.

This marsh was formerly connected by a small rivulet with Burlington bay, but this was subsequently closed by the G. W. Railway, when the cutting of Desjardin's canal through Burlington heights was completed. Into this marsh all the drainage of the Dundas valley is deposited, causing it to fill up at the rate of one-tenth of a foot per annum.

Burlington Heights. Across the eastern end of the Dundas swamp and some of its branches, are the Burlington Heights, varying from a few hundred yards to nearly a quarter of a mile in width, and over 100 feet in height, which have been an old beach, at a time when the lake level was at the same elevation, for we find that a lake beach extends along the flanks of the escarpment, both eastward and northward for a considerable distance at the same level. This is mentioned here as forming a most conspicuous terrace, and as changing the physical character of the western extremity of Burlington bay, and the outlet of the Dundas valley. Various terraces and beaches are found, both at lower levels, and also fragments at higher altitudes, or along the side of the "mountain," until some attain a height of 500 feet above Lake Ontario.

The Grand River Valley. The Grand river of Ontario rises in the County of Gray, not more than twenty-five miles from Georgian bay. Thence it flows southward, and at Elora the river assumes a conspicuous feature. Here it cuts through the Guelph Dolomites to a depth of about 80 feet and forms a *cañon* about 100 feet in width with vertical walls. At this place it is joined by a rivulet from the west, which has formed a tributary *cañon* similar to that of the Grand river itself.

The country in this region is so flat that it appears as a level plane. Farther southward the river winds over a broader bed, and at Galt the present river valley occupies a portion of a broad depression in a country indicating a former and much more extensive valley. In fact, the old river valley existed in Preglacial times, for the present stream has re-excavated only a part of its old bed at Galt, leaving on the flanks of one of its banks (both of which are) composed of Guelph Dolomites, a deposit of Post Tertiary drift, in the form of a bed of large rounded boulders mostly of Laurentian gneisses. The country for four miles south of Galt is of similar character, forming a broad valley, in which the present river flows. At this distance from Galt the river takes a turn to the south-westward; but at the same place, the old valley appears to pass in a nearly direct line with the course of the present bed (before the modern turn is made to the westward). As this portion of the valley now entered, has not to any extent been cleaned out by modern streams, it forms a broad shallow depression in the country extending for a few miles in width. Yet, it is often occupied with hills composed of stratified coarse gravel belonging to that belt, which extends from Owen Sound to the County of Brent, and called by the Canadian Geological Survey "Artemesia gravel."

It is through a portion of this valley that the Fairchild's creek flows. Many streams derive their supplies of water from the Beverly swamps, which also feed the Lindsay creek, that empties over Webster falls and flows down Glen Spencer through the Dundas valley to Lake Ontario.

The G. W. Railway, at four miles south of Galt, enters this valley and continues in it or its branches as far as Harrisburg, though the deeper depression is near St. George (a short distance west of Harrisburg). After leaving what I consider its more ancient bed, south of Galt (unless the country between the present bed and Fairchild's creek was an island), the Grand river flows southward to Paris and Brantford, having a deep, broad valley. At the latter place the valley may fairly be placed at a few miles in width, while further to the eastward the river winds in an old course, which had formerly a width of over four miles (see map). In the region of Brantford the valley is bounded by a somewhat elevated plateau. At Paris, Neith's creek enters the Grand river from the west, and has a valley almost comparable in size with that of the latter at this town. At Paris, the Grand river cuts through the plaster-bearing Onondaga formation. Similar rocks appear at various places along the river, at places where the river has cleaned out a portion of one side of its ancient valley.

At the Great Western Railway crossing, east of Paris, the bed of the

river has an altitude of 495 feet above Lake Ontario, while at Brantford it is 410 feet (this elevation may not be perfectly accurate) above the same datum. From Brantford the river winds through a broad valley, with a general easterly direction, to Seneca, where the immediate bed is about quarter of a mile wide, flowing at the southern side of a valley, more than two miles wide, and 75 feet below its boundaries, which are 440 feet above Lake Ontario (see profile on subsequent page). At Seneca the bed of the present river-course is 365 feet above Lake Ontario, or only 37 feet above Lake Erie. (The H. & N. W. Railway levels give Lake Erie as 328 feet above Lake Ontario, whilst the Report of the Chief Engineer of the Welland Canal states that the difference of level is 326¾ feet. As these two levels agree so nearly, and as the other figures refer to the railway levels, I have followed them here.) Eastward from Seneca the river continues to have its broad valley as far as Cayuga. To near this town the waters of the Welland canal feeder reach, at a height of about 9 (?) feet above Lake Erie.

From Seneca to Cayuga the direction of the valley is nearly south, but at the latter place it abruptly turns nearly to the eastward, and in a short distance it passes to a flatter country and flows over Coniferous limestone. After a sluggish flow, it enters Lake Erie (passing through a marshy country) at Port Maitland, more than fifteen miles in a direct line from Cayuga. It must be remembered that, from Seneca to Cayuga, the valley is broad and conspicuous. At only a short distance south of the river, at Seneca, the summit of the country is occupied by a gravel ridge.*

Returning to the valley of Fairchild's creek, we find the stream principally flowing in the former bed of the Grand river, abandoned a few miles below Galt since the Ice Age. This creek crosses the Great Western Railway at a level of fifteen feet below the crossing of the Grand river, at a few miles to the westward. Again, the Fairchild's creek crosses the Brantford and Harrisburg railway at an altitude of 407 feet above Lake Ontario, or a little below that of the Grand river at Brantford, although it empties into it a few miles east of the city just named.

Fairchild's creek is now of moderate size meandering through the drift for a width of two miles. This drift is in part stratified clay. The Grand

* The General Manager and Chief Engineer of the air line of the G. W. Railway have recently kindly furnished me with a profile of the railway crossing over the Grand river. A similar favor has been kindly conceded by the Chief Engineer of the Canada Southern Railway. From both of these lines of levels (about a mile apart) we find that the hard rock appears in the drift at a few feet below the bed of the river, but at a level below that of the surface of Lake Erie. The stream, at these places, occupies the eastern portion of the valley about two miles from the northern or north-western boundary of the valley, marked by the contour line of 440 feet above Lake Ontario, noticed south of Seneca, but which also occurs westward of Cayuga, near the general bend in course of the river. On both of these profiles, at about half a mile to the westward of the present site of the river, a depression in the drift occurs to a depth but little inferior to that of the present river-bed. This appears to mark the place where the ancient channel leaves what is now the modern direction of the river for a nearly direct line to the Erie basin.

river from Brantford eastward, is generally excavated from the drift deposits, although occasionally one side of the valley shows rocks of Onondaga formation, exposed by the removal of the drift in modern times. It is also desirable to call attention to the fact that in the region of Brantford, much of the Onondaga Formation is shaly and forms the surface country rock. covering a broad belt, whilst from Seneca eastward, the surface of the country is more generally covered with Coniferous limestone.

Country between the Grand River and Dundas Valleys. The watershed between these two present drainage systems is at only a short distance south-west of Copetown, and the distance in a direction from the Fairchild's to the Dundas side of this divide is less than seven miles, with an average altitude of less than 480 feet (the same as that of the Fairchild's creek as it crosses the Great Western Railway). The highest point that I have leveled is 492 feet above Lake Ontario. On receding westward from the divide, the country gradually descends to the Fairchild's creek, which, as it crosses the Brantford and Harrisburg Railway, is 407 above the lake. It is considerably lower where it enters the Grand river. The region between the divide and the Grand river is traversed from north-west to south-east by a considerable number of streams, all with relatively large valleys, cut in the drift, since the present system of drainage was inaugurated in·Post Glacial times.

The country from Jerseyville (about 465 feet above lake) slopes gradually to the Grand river, from six to eight miles distant to the southward.

On examination, it may be seen that the country is too high to permit the Fairchild's creek or Grand river, as they are at present situated, to flow over the height of land into the upper portion of the Dundas valley. As referred to before, the Niagara limestone forming the summit of the escarpment at Ancaster and eastward has a height of about 500 feet. These beds dip at only about 25 feet in a mile (to about 20 degrees west of south) and are not generally covered by a great thickness of drift, but in many places are exposed on or near the surface. Westward of Ancaster these limestones are nowhere to be found, but the country is only covered with drift. At a short distance west of this village, we find streams flowing north-easterly and easterly with very deep valleys in the drift, indicating the absence of the floor of limestone to a depth of over 250 feet below the surface of the escarpment. But on going westward we find that the streams have not cut to an equal depth, but still running deeply through drift. Eventually we reach the divide, after which we find that other systems of streams also cut deeply in the drift running in a south-easterly direction to join the Grand river; but the Niagara limestone is absent from a considerable extent of country.

On the northern side of the Dundas valley the escarpment after reaching Copetown is buried by the drift. Although the line of buried cliffs recedes somewhat to the northward of the Great Western Railway, yet there are occasional exposures, as at Troy and other places in Beverly and Flamboro, where the underlying limestones come to the surface. At

Harrisburg the limestones are known to be absent for a depth of more than 72 feet, as shown in a deep well in the drift.

In the town of Paris one well came upon hard rock at 10 feet below the surface, whilst another at 100 feet in depth, reached no further than boulder clay. This last well must have been in a buried channel of Neith's creek, as outcrops of gypsum-bearing beds of the Onondaga Formation frequently occur near the summit of the hills. From what has just been written, it is easily seen that the Niagara limestones are absent from a more or less horizontal floor (which is over 500 feet above the lake, on both the northern and southern sides of the Dundas valley) which continues from Dundas westward to near Harrisburg, where it meets a portion of the Grand River valley. But almost immediately west of Ancaster we find streams running northward at right angles to the escarpment, and cutting through drift to the depth of almost hundreds of feet. In fact, if we draw a line from Dundas to northward of Harrisburg (a mile or two), and another from Ancaster southward to the Grand river, we have two limits of a region where the limestone floor has been cut away from an otherwise generally level region. The southern side of this area is the southern margin of the Grand River valley, between Seneca and Brantford, and the western boundary is composed of Onondaga rocks east of Paris (which perhaps forms an island of rocks buried more or less in drift).

Additional proofs may be cited. About a mile south of Copetown a well was sunk to the depth of 100 feet before water was obtained. At two miles south east of the same village there is small pond only 240 feet above Lake Ontario, or more than 260 feet below the neighboring escarpment. This is in drift. Again, at a mile north of Jerseyville, the country has a height of 465 feet, with a well in the surface soil to a depth of 40 feet. A small rivulet flows in a valley a few hundred yards south of the last named well which has a bed 435 feet above the lake. At about a mile west of Jerseyville, the altitude is 468 feet with a well 52 feet deep. Again, at about two miles west of the same village, near the county line, the altitude is 460 feet, with a well 57 feet deep (the bottom being lower than the Fairchild's creek more than three miles to the westward). About a mile north of the last named station is a ravine 436 feet with the adjacent hills forty feet higher, and rising in a mile or two to about 500 feet. All these wells are in the drift. From exposures near Ancaster, it appears that the unstratified drift has not an altitude of much more than 400 feet. And as we know that some of these superficial beds are stratified clay, and over most of the country just described not a boulder is to be seen, neither on the surface nor in the material taken from the greater portions of the wells, it is probable that the water is only obtained on reaching the more porous boulder clay below. It has also been noticed that two wells, at least, are 100 feet deep before reaching water, therefore we may fairly place this as about the inferior limit of stratified superficial clays. By reference to the accompanying map, it will be seen that westward of the meridian of Ancaster there is an area of over 100 square miles, where the Niagara floor is

known to be removed everywhere to a depth of 100 feet, and in its eastern portion to more than 260 feet, and still nearer Lake Ontario to a measured depth of more than 200 feet below its waters.

III. Topography and Hydrography of Lakes Superior, Michigan, Huron and St. Clair.

As the origin of all our great lakes is so closely related, it will not be out of place to describe briefly some of the features of the upper lakes that appear most striking. In the present paper it is only intended to call attention to some of the existing physical features of these great basins of water that appear to show a relation which existed in a more or less common origin of all our lakes. Though I have frequently visited many localities on these lakes, for this portion of the present paper I am particularly indebted to General Comstock, Superintendent of the U. S. Lake Survey, who kindly furnished me with the lake charts.

Lake Superior. This lake may be described as a large basin with a level or gently undulating bottom and steep margins. The mean depth may be placed at 800 feet below its present surface. Very few soundings exceed 900 feet. Of these, one near the centre of the basin is 954 feet, and another, not far from Duluth, is 1026 feet—the maximum depth of the lake, as shown by the hydrography.

The depth of the lake at three or four miles from the shore is generally as great as in its centre; in fact, it is often deeper near the shore on its north-western side. However, about the Apostle islands, between the Pictured rocks and St. Mary's river, and in some of the bays, the waters are shallower than in the open lake, with their floors more or less gradually sloping as they recede from the land. As is well known, the lake is generally surrounded by crystalline or metamorphic rocks, which rise from several hundred to even twelve or thirteen hundred feet above its surface. In short, the near shore hydrography simply shows that the present submerged margins of the lake are composed of the bases of the same rugged hills that surround it above the water. The margin of this mountain-bound basin forms a strong contrast with its floor, which, at most, is only a slightly undulating plane, extending for nearly its whole length and often for little less than its breadth, excepting in its south-eastern portion and some other places referred to above. In fact, the lake bottom is quite as level as most extensive planes which are now subjected to sub-aërial action.

That this great plane is not covered with any great depth of drift-deposit (excepting locally) appears evident on examining the character of the bottom of the lake in the soundings just off Keweenaw point, and those to the northward. In the various localities hard and rocky bottoms are alike found in both places, at the same depths, so frequently that they cannot be regarded as only rocky eminences protruding through the silt covered bottom which is generally observed.

The general direction of the deepest channel, for more than 200 miles along the north-western margin of the lake, appears to point to a river

course in the region of its south-western extremity, and the few deeper holes to have been produced by some receding cascade from the adjacent shore to which there appears to be a transverse deep channel south of the mouth of Gooseberry river.

Again, Prof. N. H. Winchell calls attention to the depression in the low country between the Chocolate river (east of Marquette), and Train bay (near the Pictured rocks), as the only place where there could have been connection between the basins of Lakes Superior and Michigan. It may be remarked that some of the deeper soundings put in towards this portion of the coast, whilst, to the westward and eastward, the present lake bottom slopes more gradually. The soundings, however, that are near the shore, show a rocky bottom, excepting north of Laughing Fish point (Sable river), and along a narrow channel north of the mouth of Chocolate river. The lake is very shallow for some distance westward of the St. Mary's river.

Lake Michigan. This lake may be said to consist of a broad long plane, the northern half having a mean depth of about 600 feet, whilst the soundings in the southern half are not much more than half that measurement. The deepest sounding recorded is 870 feet, in the latitude of the southern end of Green bay. Throughout the whole length, the lake appears to be traversed by a deep channel, and in the northern end by more than one. Although the pitch of the bottom from the shore line is more or less gradual—generally less than 40 feet in a mile—yet, along the eastern side there is a precipitous escarpment extending for a considerable distance, which in one place suddenly descends, in a horizontal line of little over a mile, from 17 to 93 fathoms, or 456 feet, and increases 60 feet more in the distance of another mile.

The conspicuous channels in the submerged plane extend far northward to near the end of the lake. An interesting sounding east of the mouth of the Manistique river shows a depth of 448 feet, at a distance of two miles from the shore, whilst all the adjacent depths do not exceed 11 fathoms. This appears to be a continuation of the deep soundings, ten miles to the southward, but the surrounding lake bottom is covered with drift to a great depth, wherever the Niagara limestones have been removed. It is more than probable that this great depth is in a rock-bound channel of an ancient water course, which elsewhere has been filled with drift. It seems probable that it was a portion of a buried channel extending through the valley of the Manistique lakes to the depression in the country south of Lake Superior, alluded to above, and formed a Preglacial connection between the valleys of Lakes Superior and Michigan. Prof. Winchell regards the valley between the two lakes along the Chocolate and White Fish rivers (the latter emptying into Little Baie De Noc), as indicating the ancient connection. This route seems less favorable, as both Little Baie de Noc and Green bay are shallow compared with Lake Michigan, for the greatest depth, which is near an outlet through Portes des Mortes, is only 32 fathoms, whilst generally the bay does not exceed 100 feet.

Green bay is separated from Lake Michigan by a Niagara escarpment facing the westward, and rising two or three hundred feet above the waters. There appears not to have been any closer connections between these two basins at any previous time than at present, excepting when the waters were at a higher level. We are told that from Green bay for 400 miles to the Mississippi river, a broad, low depression occurs in the country and may have been a former outlet for Lake Superior. This valley is filled with drift even if it ever had a sufficient depth.*

Grand Traverse bay has a considerable depth in both of its branches, especially in the eastern. Here we find depths to 612 feet, whilst its northern mouth is now filled, so that it does not exceed 120 feet.

The north eastern portion of the basin of Lake Michigan has a general depth of less than 100 feet, but with deeper channels running through it. Many of the soundings about the Straits of Mackinac show a rocky bottom at no great depths. The channel between the 10-fathom contour margins is not much more than a mile and a half wide, and though generally shallower, contains a hole 252 feet deep. In proceeding outward, the deepest channel passes northward of Mackinac island, having a depth not exceeding 216 feet, and a width of less than a mile.

Again, a depression of the country extends from near Chicago, on Lake Michigan, towards the Mississippi river, which, in some places, is known to be filled with drift to a depth of more than 200 feet, according to Dr. Newberry. This is along the Illinois river, whose valley is from two to ten miles wide ; whose mouth is 200 feet lower than Lake Michigan ; and whose upper streams, near Chicago, are only a few feet higher than the neighboring lake.

Lakes Huron and St. Clair. Of these water basins we can make four divisions. The first section may be made to include the shallow basin south of a line drawn from Thunder bay, or Presqu' Ile, to Kincardine, in Canada, and Lake St. Clair. The second basin comprises the deep channels of Lake Huron, and extends northward to the Manitoulin islands and the Indian peninsula ; the third, the north channel between the Manitoulin islands and the Huronian hills, to the northward ; the fourth, Georgian bay proper.

The first of these divisions is represented by shallow water, seldom thirty-

* Since writing the above, I have fortunately been able to see General Warren's Report on the Transportation Route from the Mississippi river to Green bay (*via* the Wisconsin and Fox rivers). In this report we find that the bottom of the valley alluded to in the text has a maximum height of 208.8 feet above Green bay, and also that Lake Winnebago (on Fox river) is 169 feet above the same water. This small lake discharges by the Fox river, which flows over hard limestones down a series of rapids. Therefore Green bay never discharged its waters into the Mississippi river, and this depression in the country between the Great river and Lake Michigan (the Green bay portion) was not a former outlet of Lake Superior, since it was within about 200 feet of the present level. This fact strengthens the probable correctness of the suggestion that Lake Superior emptied into the northern end of Lake Michigan directly. Also, Green bay has evidently the character of a fiord. The outlet of Lake Michigan could only have been by the low country along the Illinois river.

five fathoms deep, but with a channel of about fifty fathoms depth running through it, towards the direction of the north angle of the Au Sable river, near Brewster's mills. Saginaw bay, belonging to this section, is like Green bay, shallow even at its mouth, where it is less than 100 feet deep.

Lake St. Clair is a flat plane, with its bed varying from 18 to 21 feet below its surface, and is altogether modern.

At Detroit the drift is 130 feet deep. The three south-western counties of Ontario are low and flat, and covered with drift varying generally from 50 to 100 feet in thickness below the level of Lake Erie. In places it is known to be absent to a depth of 200 feet below the same lake in portions of a buried channel to be noticed below. In fact, all the evidence appears to show that the southern end of Lake Huron and the western end of Lake Erie, with the intervening region, constituted one plane underlaid by a considerable depth of Erian shales, reposing on the thick development of Coniferous limestone, and traversed by deep channels running through it.

The section of Lake Huron under consideration is mostly excavated out of Upper Erian shales in a direction at right angles to the trend of the formations. The denuding action was lessened when the waters in the deeper northern part of the lake subsided to a level having a southern margin bounded by hard Coniferous limestone, covered to no very great depth with Upper Erian shales subjected to only sub-aërial action—the whole traversed with water courses in deep channels.

The second division into which, for convenience, I have made of Lake Huron, is that portion between the line drawn from Presqu' Ile to Kincardine, and the Manitoulin islands to the northward. This is the deepest portion of the lake and extends in a direction running from north-west to south-east. It consists of a broad plane traversed by several deep channels. The average depth of this plane below the surface of the lake does not exceed 75 fathoms, although there are channels much deeper, one of which is represented by a depth of 117 fathoms. There is also one isolated sounding, which reaches 125 fathoms or 750 feet, this being the deepest spot known.

The deeper channels appear to lead from the northern portions of the lake, and unite as they proceed southward, being separated by elevations indicating peninsulas or islands. Two of the principal channels appear to proceed from Mississagua strait (between Manitoulin and Cockburn islands), and from south of Manitoulin island, eastward of the Duck islands. However, the channels in the marginal portions of the lake are generally more obscured by drift or silt than towards the central waters. The channel, if such you can call it, proceeding from the Mackinaw straits is of inferior depth to those leading from the more northern end of the lake.

This portion of the lake is excavated out of the rocks of the various formations from the Niagara to the Coniferous limestones. But most largely out of the more or less soft rocks of the Onondaga group, along the strike of these formations, thus giving the eroding agencies the power of removing the softer basal rocks, and of producing an escarpment of the Conifer-

ous limestone looking to the northward, until it was finally undermined, and worn back to its present position, submerged beneath the shallower waters of the southern portion of the lake, or buried in drift deposits.

On the northern side, the lake has not made so much encroachment, as it is bounded by the hard Niagara limestones of the Manitoulin islands, and the Indian peninsula of Canada, the strata dipping down beneath the lake. Yet it must be noticed that these rocky shores are indented by numerous deep bays transverse to their directions.

The North Channel. This is generally a shallow water, the greatest depth being only 204 feet. To the northward, we have the Huronian rocks forming the boundary. The islands, especially towards the eastward, and near the whole north shore, are generally composed of Trenton limestone.

The southern margin of the channel, bounded by Manitoulin and the other islands, is often composed of Hudson river, more or less, shaly rocks, overlaid by the Niagara limestones (where not removed by denudation), constituting an escarpment facing the northward. In fact, the whole of the north channel is principally scooped out of the Hudson River Formation, which attains a considerable thickness in this region.

Dr. Robert Bell states that he has observed fifteen anticlinal folds traversing the group of the Manitoulin islands; and it is in these that we find the great indentations, and lakes in the islands, as well as the straits which separate them. Doubtless many of the southern ends of the Manitoulin lakes and channels are filled with drift. For example, the mouth of South bay is only 33 feet deep, whilst the upper portion is generally deep, one place giving a sounding of 156 feet.

In fact, the north channel may be considered as a broad continuation of the Spanish river westward. The Mississagua river points directly to Mississagua straits, which are 204 feet deep, as deep as any part of the channel itself. Thessalon river has a direction towards False Bay De Tour, which is 186 feet deep. Vermilion river flows amongst the islands west of Cloche mountains and probably had a connection to Lake Huron through some of the buried channels across Manitoulin islands, as between Manitouaning and South bays.

The narrow channel between the peninsula of Cloche mountains and Manitoulin island is less than 60 feet deep and appears to be a modern connection with Georgian bay.

Georgian Bay. The eastern and northern margins of this bay are composed of crystalline rocks; the south-eastern, of Trenton limestone; whilst the western is made up of the Hudson River shales capped with the Niagara limestone, on the Indian peninsula and Manitoulin island. This basin is principally excavated out of the Utica shale, and the somewhat harder rocks of the Hudson River Formation. It lies along the junction of the various formations, and thus on the removal of the lower soft layers of rock, an escarpment was produced which has subsequently and slowly continued to be undermined.

In the channels connecting this bay with Lake Huron, there are many

small islands separated by shallow water. Yet in one place there are two deep soundings reaching 51 and 42 fathoms. The bay itself is much deeper than these passages, for there is an escarpment submerged to a depth of 498 feet immediately off the Indian peninsula, at Cabot's Head, which is itself 324 feet above the bay. This peninsula is deeply indented with bays or fiords.

There is a depression from the southern end of the bay, through the valley occupied by Simcoe, Balsom, Rice and other lakes, to the Trent river, emptying into the Bay of Quinté, an arm of Lake Ontario. This will be alluded to again.

IV. The Buried River Channel in the Dundas Valley and its Extensions.

That the Dundas valley is that of an ancient river valley now buried to a great depth with the *débris* produced in the Ice Age, becomes apparent on a careful study of the region. However, until a key was discovered the mystery of its origin was found to be very obscure. My own labors at studying this region may fairly be stated as the first systematic attempts at the solution of the present configuration of the western end of Lake Ontario and the adjacent valley. Assertions have been made that it was scooped out by a glacier, but this wild hypothesis was only a statement made without any regard to facts.

From the description of the topography, given in Section II, of this paper, it will be seen that the apparent length of the rock-bound valley is six miles, with a width of over two miles; then it widens suddenly to four miles (with concave curves on both sides), after which it gradually increases in width as it opens into Lake Ontario. The direction of the axis of the valley is about N. 70° E. The summit edges of the rock-walls on both sides are sharply angular and not rounded or truncated. This angularity is not due to frost action since the Ice Age, to any extent, as is shown by the character of the talus. The rocks of the summit are frequently covered with ice markings, but I am not aware of any locality where they have been observed as being parallel with the true direction of the valley, but on all sides one can observe them (sometimes at only small angles of less than 30 degrees) making conspicuous angles with its axis. One exception may be made to this statement. On a projecting ledge of Clinton limestone, at Russel's quarry, near Hamilton, at a height of 254 feet above the lake, and 134 feet below the summit of the "mountain," after the removal of some talus, I observed that the surface was polished, but with scratches so faint that they could scarcely be compared with those of fine sandpaper on wood; and the direction, if determinable, was parallel with the overhanging escarpment. There are many tributary *cañons*, which are evidently of greater antiquity than the Ice Age, which could not have excavated by the present streams, and are at all sorts of directions compared with the striated surface of the country.

The topography of the lower lake regions precludes the idea of a glacier flowing down the valley to the north-eastward. Again, as the direc-

tion of the ice was towards the south-west, the waters from the melting glaciers could scarcely flow up an escarpment many hundreds of feet in height. Even if the Niagara escarpment did not exist elsewhere, the non-parallelism of the striæ, and edges of the escarpment with their angular summits, is sufficient to prove the non-glacial origin of the valley in the hard limestone rocks. Moreover, at the eastern end of the narrower portion of the valley, there are two concave curves facing the lake, which of necessity would have been removed if such a gigantic grinding agent had been moving up the valley.

This glacier-origin of the valley being an absolutely untenable hypothesis, I sought for some fluviatile agent capable of effecting the present configuration of the region. At the time, no idea occurred that even the great valley of the present is only a miserable remnant of one of gigantic proportions obscured by hundreds of feet of drift. The question arose, could Lake Erie have ever emptied by this valley? This suggestion did not hold its ground for any length of time, because the present levels are all too high. Near Galt, the traces of the true origin first presented themselves. A branch of the Great Western Railway extends from Galt southward for about four miles in the valley of the Grand river, after which, without making any important ascent, it passes into the broad older valley, described above as that in which Fairchild's creek now flows. After a careful examination of the region, and of the railway levels, I came to the conclusion that this was an old buried valley. It then became apparent that if the Grand river had occupied the site of the Fairchild's creek, that the latter probably flowed down the Dundas valley, and that the Grand river, being one of the largest of the rivers of Ontario, might have been a sufficient cause for the great excavation at the western end of Lake Ontario. Having procured all the levels that bore on the subject which were available, it became necessary to connect several places myself by instrumental measurements, which work was accomplished last July, with the aid of Prof. Wilkins. As the whole floor of Niagara limestones is absent, as has previously been shown, the proof that the ancient Grand river flowed down the Dundas valley was completed, and of this discovery there was published a local notice last August. Significant and interesting as this fact was, relative to the change of systems in our Canadian drainage, a still more important issue was involved. When taking the levels between the Dundas valley (modern) and the Grand river, it was found that the whole calcareous floor was removed from a basin several miles in width, and that all the wells were sunk to a considerable depth in the drift before water could be obtained. On glancing at the map it will be seen that the Grand river from Brantford to Seneca meanders through a broad course, which in its ancient basin is several miles in width, but that from Seneca the valley is narrower, and the course of the stream more direct, as far as Cayuga. At Seneca the valley is two miles wide, and seventy-five feet deep. Also the bed of the Grand river at Seneca is in drift which is only 37 feet above the lake into which it now empties. As has been pointed out in the section

on the topography, this broad valley continues to Cayuga within a few miles of the lake, whence its former probable course was by a nearly direct line to Lake Erie, now filled with drift, near the present bend in the river towards the eastward. At Cayuga, the rock beneath the drift-bed of the river is below the lake level, on the margin of its ancient valley. (See note, Section II.)

Having observed the connection between the Dundas valley, Grand river and Lake Erie, it dawned on me that I had established the knowledge of a channel having a very important bearing on the surface geology of the lake region. It now became apparent that Lake Erie had flowed by the Grand river reversed to a point west or north-west of Seneca, and thence by the Dundas valley into Lake Ontario; also that the upper waters of the Grand river, previously discovered as passing down the Dundas valley, were really tributary to the outlet of Lake Erie, and joined it somewhere south of Harrisburg; and that the basin between the Brantford (and the Grand river of to-day) and the Great Western Railway, at Copetown, formed an expanded lakelet along the course of the ancient outlet of Lake Erie, scooped out of the softer rocks of the Onondaga Formation before noticed. As the waters excavated a bed in a deeper channel, of course this lakelet would become an expanded and depressed valley, such as we often see amongst the hills of drift, at a short distance westward of Dundas. Possibly the Grand river divided and flowed around an island, the western side of which is occupied now by the town of Paris. At any rate, Neith's creek, at that town formed a large tributary to the river then flowing down to Lake Ontario.

Along the course from Cayuga to Lake Ontario all obstacles to the outlet of Lake Erie appear to be removed. But along the present course of the Grand river, eastward of Cayuga, the waters flow over Coniferous limestone. But this difficulty is removed on observing that the river, filled with drift, approaches Lake Erie to within a direct distance of about six miles, but that at this place it leaves its southward course and also its conspicuous valley and flows eastward, in the same manner as the Niagara river, above the Whirlpool, left its old choked-up outlet by the valley of St. David, and cleaned out a new channel for itself through several miles, in hard rock, from Queenston southward.

We have recently seen by a note in the second section of this paper, that the Grand River bed is near the eastern\margin of its ancient valley at Cayuga. From northward of this town, at about half a mile to the westward of the river, a deep depression in the drift indicates the deeper portion of the ancient river as it left the modern channel direct for the Lake Erie basin. Also along this route the hard rock is known to be absent to a depth below the surface of Lake Erie.

In Ohio, the Geological Survey considers that Maumee river emptied into the Wabash. If the waters of Lake Erie ever passed by this route into the Mississippi river when they were at no higher level than at present, then there must be a channel buried to a depth reaching at least 170 feet above

the lake, as that is the elevation of the divide between the upper waters of these two rivers.

The outlet of Lake Erie, indicated in this paper, is known at many places along its route to have no rock-bed for a distance below the surface of the higher lake, and to a probable depth shown below sufficiently great to empty Lake Huron.

Again, Mr. Carll has shown that the Allegheny drainage passed near Dunkirk into the Erie basin at a place just opposite to its outlet, as indicated by the present writer.

Much of the Dundas valley is underlaid by stratified Erie clay, which is known to extend to a depth of 60 feet below the surface of Lake Ontario, according to Dr. Robert Bell. In the upper part of the valley, streams have exposed some deposits of unstratified clay filled with angular shingle,

Fig. 2.

←S. N.→

FIG. 2.—1. Hudson River Formation; 2. Medina shales; 3. Niagara and Clinton dolomites with some shales. A, C, D, B, modern valley at meridian of Burlington Heights; a, C, D, b, modern valley at meridian of Dundas; a, c, d, e, b, sections across, deeply excavated in beds of streams in western part of the Dundas valley; 4. Boulder clay filling ancient valley; 5. Erie clay; 6. Talus from sides of escarpment; 7. Old beach, 108 feet above lake at Burlington Heights. G. Desjardin's canal leading from Dundas marsh to Burlington bay; W, W, well at Royal Hotel, Hamilton; W', another well at Dundas; L. O. level of Lake Ontario; L. E. level of Lake Erie. Horizontal scale, 2 miles to an inch; vertical scale, 400 feet to an inch.

derived from the thin beds of limestone forming the upper portion of the Niagara Formation. In the eastern portion of the valley, the Erie clay is overlaid unconformably by brown Saugeen clay or loam (stratified). In the upper portions of the valley the hills are capped by brown clays or

sands. But along some of the hillsides excavated so deeply in the drift, we find old beaches resting unconformably on boulder clay.

Near the centre of the city of Hamilton, in the wider portion of the Dundas valley, a well was sunk to the depth of over 1000 feet. This well revealed a most interesting fact. Though known to me several years ago, I did not apply it until recently to its true bearing, since discovering the origin of the Dundas valley. Mr. J. M. Williams sunk this well, at the Royal Hotel, in Hamilton. He told me several years ago that he had to sink through 290 feet of boulders, before coming to hard rock, thus causing the outlay of a large sum of money in excess of his calculations. Unfortunately, this well-record has been lost by fire. At that time, the fact was so fresh in his memory (improved by the extraordinary cost of the well) that his statement could be relied on, being experienced in well-borings. The mouth of this well is 63 feet above Lake Ontario, and therefore the hard rocks are absent for a depth of 227 feet below the lake surface. See section, Fig. 2.

As the valley is five miles wide at this place, and as the well is only about one mile distant from its southern side, it becomes apparent that the valley in the centre must have been much deeper. Moreover, if we produce the southern side of that portion of the valley, which is over two miles wide, we find that the well is less than a quarter of a mile away from it. Now if we connect the top of the Medina shales (240 feet above Lake Ontario) with the base of the drift in the well, and produce it to the centre of the valley, it would indicate a central depth of over 500 feet. At the base of the drift there are nearly fifty feet of Medina shales, below which are the Hudson River rocks (more or less calcareous and arenaceous, mixed with the shales). This harder formation along the bed of a river would be less extensively removed by aqueous action than the overlying Medina shales, especially as the pitch of the waters would be much lessened. This graphic method of calculation seems as perfectly admissible here as it does in determining other constants of nature. However, I have placed the estimated depth in the section at about 70 fathoms below the lake surface, which depth is perfectly compatible with the soundings of the lake of no very great distance to the eastward. Even this depth gives only very gentle slopes from the sides of the river valley. It should be remarked that Burlington bay is excavated from stratified clays in places to a depth of 78 feet. But this water is silting up comparatively quickly.

Now we have seen that the deep excavation in the Dundas valley and westward is cut through more than 250 feet of Niagara and Clinton rocks, mostly of limestone, and to a depth in the Medina shales, so that the total known depth of the *cañon* is 748 feet, but with a calculated depth in the middle of the channel of about 1000 feet. This depth for a *cañon* is not extraordinary for Eastern America. In Tennessee there are river valleys excavated to a depth of 1600 feet, and in Pennsylvania Mr. Carll reports others to be equally deep.

Again, this Preglacial river explains the cause of the present topography

of the western end of Lake Ontario. The drainage by this river swept past the foot of the submerged escarpment of Lake Ontario, described in preceding pages, until it passed the meridian of Oswego.

With such an outlet, and with the ancient Grand River valley buried to an equal depth, we have an easy solution to the problem of the drainage of Lake Erie. See section, Fig. 3.

Fig. 3.

Section of Grand River Valley at Seneca.

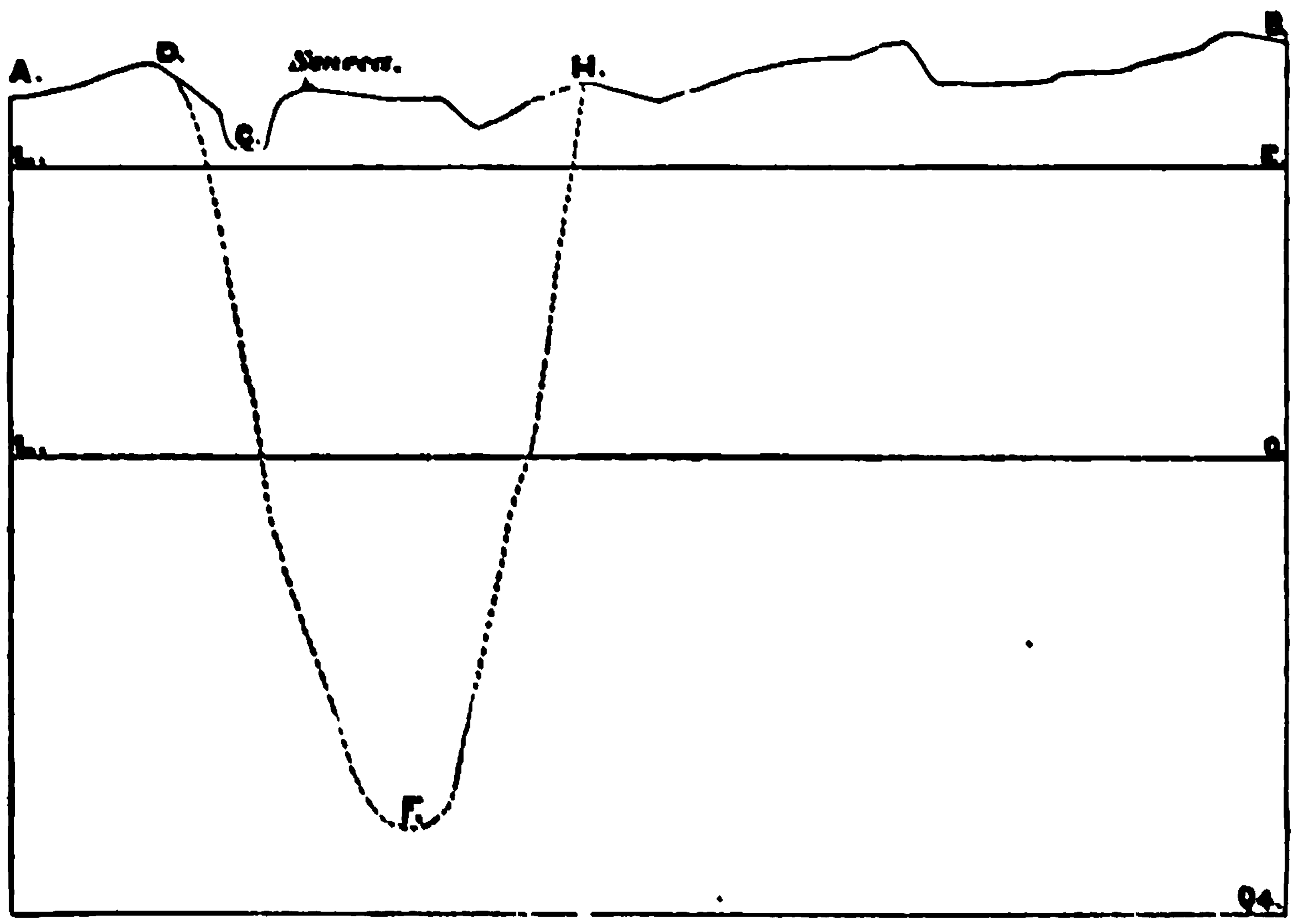


FIG. 3.—Section of Grand River valley at Seneca. A, D, C, H, B, is the profile of the H. & N. W. Railway; horizontal distance, 2 miles to an inch; vertical, 400 feet to an inch. C, represents position of Grand river; D, C, H, valley two miles wide and with maximum depth of 75 feet. L, E, level of Lake Erie; L, O, level of Lake Ontario; D, F, H, probable depth of buried valley.

Attention has been called in this paper to the deepest portion of Lake Erie being southward of Haldimand county, and about the end of Long point, and extending transversely towards the Pennsylvania shore.

So far, our remarks have applied to Canada. If we turn towards the American shore, we will see that the observations made there go very strongly in support of what has been written.

Several years since Dr. Newberry, Mr. Gilbert, and others, called attention to the deeply buried valleys of the Cuyahoga, Chagrin, Grand, Maumee and other rivers in Ohio, which emptied into Lake Erie much below their present levels. The Cuyahoga has its channel buried to a depth of 228 feet below the surface of Lake Erie of our time, whilst the deepest water in the neighboring portion of the lake is less than a hundred feet.

In Report III, of the Pennsylvania Geological Survey, issued in November, 1880, Mr. John F. Carll published excellent maps of the Preglacial drainage of that State and the neighboring portions of the adjoining States. This report on the Preglacial rivers is the result of five years' labors in the oil regions, and many of Mr. Carll's results have been derived from the facts made known by the borings for mineral oil.

Besides calling attention to the very deep valleys of erosion amongst the mountains, Mr. Carll has shown that in the oil regions the river valleys are frequently filled with drift to a depth of from 200 to 450 feet. In fact, nearly all the present rivers flow over beds deeply filled with drift. The map of the Preglacial drainage shows that the upper waters of the Allegheny emptied by the Cassadaga river, reversed, into Lake Erie, near Dunkirk, and had for tributaries many other streams now flowing southward; for example, the Conewango. These streams drained an area of 4000 miles, which now sends its surplus waters to the Ohio river. Again, the French and other rivers, now emptying southward from the Conneaut basin, emptied in Preglacial times into Lake Erie, westward of Erie city. Again, the Chenango, Connoquenessing, Mahoning and other tributaries of the Beaver river (itself now emptying into the Ohio) flowed northward, by the Mahoning river reversed, into the State of Ohio, to near the sources of the Grand and Cuyahoga rivers. Hence Mr. Carll did not continue its course, on the map, but from the study of the levels and character of the country, as described by the Geological Survey of Ohio, I have connected it with the Grand river of Ohio, as represented on my map. Thus we find three large areas now flowing southward formerly emptying into the Lake Erie basin.

The deepest portion of Lake Erie is between these ancient river mouths and the ancient *débouchement* of the Erie drainage by the Grand river of Ontario, as described in these pages.

Thus we have shown a consecutive system of drainage of the former waters of the buried channels into Lake Ontario, and thence running along the foot of the submerged escarpment of the latter lake to its eastern end, receiving the Genesee and other large rivers along its course. In a portion of the present notes, the writer will endeavor to make known still further the buried channels of Ontario, which exist between Lakes Huron and Erie when treating of the origin of these lakes.

The remaining portion of this paper will be devoted to the subject of the origin of our great lakes. The writer does not wish to enter here into the discussion of the drift deposits, and their origin at the present time, but to reserve it until the final report on the surface geology of the Western End of Lake Ontario. Yet the facts brought to light in this study have an important bearing on the great controversy of the Glacial Drift, and lead one to the conclusion that the Ultra-Glacial theorists stand on uncertain grounds.

V. Origin of our Lower Great Lakes.

On a former page of this paper attention has been called to Prof. Winchell's observations of an outlet from Lake Superior by way of Little Baie

de Noc, and also my theoretical divergence slightly from this view. That an outlet did exist somewhere in the region between Lakes Superior and Michigan, seems certain, of course, we do not know to what depth, but from the evidence brought forward from the soundings in the northern end of Michigan lake to at least half the depth of our greatest lake, and probably to the whole depth.

There appears also to have been an outlet from Lake Michigan, near Chicago, emptying into the Mississippi river. These two lakes both lie outside of the study of the present paper, but before passing to the other lakes, let us note certain facts which present themselves to the view of the writer. Without taking up the bibliography of the subject, it may be stated that some have regarded the origin of the lakes as being due, to a greater or less extent, to the geological valley, formed at an earlier date. Of our five great lakes, certainly not more than one can possibly come into this category—that is Lake Superior. Not even the northern side of the north channel of Lake Huron, bordered by crystalline rocks, could be included. The writer even doubts that Lake Superior is essentially anything more than a valley of erosion, and if it be, it remains to be proven. Yet its position was probably determined to a greater or less extent by the orography of the region, and its excavation appears to have been principally by erosion. Although the lake is in the region of very ancient continental oscillations, there are no evidences of different elevations, and subsidences in different portions of the lake basins. Five years ago, I pointed out that Superior was eminently a region liable to atmospheric erosion, as the great volcanic seat situated about the Keeweenaw Point, in Presilurian times, would tend to weaken the strata. All who have made a study of the three miles in thickness of the copper-bearing rocks, pitched at various angles, whether on the northern or southern shores, and crossed by numerous faults, know that they are particularly liable to irregular atmospheric decay. As an example, we have remaining an excellent case in that in which Portage lake lies, now a valley transversely situated in the Keeweenaw hills, and excavated to a depth of six or eight hundred feet. In the narrow channel between Houghton and Hancock the waters are 60 feet deep and underlaid by a considerable depth of silt.

According to both Professors Dana and Whitney's explanation, fiords are valleys of erosion, when the land was at a higher level; but as a necessary condition, high hills or mountains should be near a shore, so as to give pitch to the descending waters; from this definition we can fairly consider most of the bays of Lake Superior, Lake Huron, and those about the Niagara escarpment in the region of the Green bay extension of Lake Michigan, as belonging to this category.

Lake Michigan is nearly deep enough to remove all the waters of Lake Superior. Such deep places as the 171-fathom hole north-east of Duluth could easily be produced by a cataract, the same as the water in the Niagara river is so much deeper than its rock-bound outlet into Lake Ontario. Moreover, the peculiar form of the south-western extension of Lake Supe-

rior can only be explained as having in part been produced by water, running in one direction or the other, as the St. Louis river now empties, at Duluth.

That the other lakes are not occasioned by a geological depression or elevation can be easily seen, as they are exclusively excavated from stratified rocks lying almost flat, perhaps dipping in no place at higher angles than 40 feet in a mile.

The North channel and Georgian bay of Lake Huron belong to a separate category from the rest of the lakes. I do not deny, as far as Lake Ontario and the north-eastern half of Lake Huron are concerned—both of which are excavated at the junction of hard and soft strata and parallel with their trend—that they might have had the direction of their first rivers determined by continental elevation. Yet, in no other respect are these lakes now occupying geological valleys.

Dr. Newberry is of the opinion that the valley of Lake Michigan was separated from that of Huron at the Straits of Mackinac, even at a comparatively recent period. I concur with this view entirely. Lake Michigan is 22 fathoms deeper than Lake Huron, and therefore could in no natural way have ever been entirely drained by the latter lake. There is no evidence of local subsidence, and the glacier theory is absolutely untenable, as will be seen further on. In the Beach Epoch of the Ice Age this separation seems to have existed, as it is stated that the highest beach north of Lake Michigan is 65 feet, whilst that on the island of Mackinac is more than 250 feet above these waters. We know that there are several correspondingly high beaches along the margins of the basin, including the three great lower lakes.

Thus we can cut off the two western waters of the great chain of American lakes from our subject and leave them for future inquiry.

Whether the above named outlets of Superior and Michigan are sufficiently deep to have drained their basins, at the time when we know that the Mississippi valley was several hundred feet higher than at present, remains to be shown.

The writer will now deal with those waters to the eastward, and see what difficulties have been removed and what still remain, for Lake Ontario is nearly a hundred feet deeper than the deepest sounding of any of our upper lakes.

Dr. Newberry prophesied that an outlet for Lake Erie into Lake Ontario would be discovered near the Welland canal. This outlet in an unexpected position I have discovered, and in a position which explains more perfectly the cause of the topography of Lake Ontario than any that could have been discovered forty miles to the eastward. Moreover, I have shown that its depth is not only sufficient to empty Dr. Newberry's deep Cuyahoga (228 feet below Lake Erie), or the ancient rivers, worked out by Mr. Carll (the most systematic study of fluviatile geology that has been done on this continent), but also sufficiently deep to empty the deepest waters of Lake Huron into Lake Ontario.

When was the advent of such a drainage system for this continent? Some of our American friends, who have advocated the sub-aerial and fluviatile origin of the lakes, have placed it back to the Devonian Age. About the commencement, we know nothing. It would be safer to place it after the Palæozoic time, for probably some portions of the Province of Ontario were covered with carboniferous deposits, as well as Michigan and Ohio, which have subsequently been removed by denudation.

Outlet of Lake Huron. The south-western countries of Ontario are dotted with borings for oil. From these well-records, one can draw only a single conclusion, that they are underlaid by drift (mostly stratified and perhaps wholly) to a depth of not more than 100 feet below the surface of Lake Erie, and that generally to not more than 50 feet. There are deeper borings in drift, it is true, but these may be fairly considered as in buried channels. For instance, at Detroit the drift is 130 feet deep. Again, at Port Stanley, it is 150 feet below the surface of the lake; at Vienna it is 200 feet below Lake Erie. If we draw a line from near the northern angle of the Au Sable river (of the south) to east of Vienna, we have a boundary to the deeply drift filled basin of south-western Ontario; for at Tilsonburg, St. Mary's and elsewhere (just east of this line) the hard limestones come to near the surface of the country much above the level of Lake Erie. Excepting a few shales, at Kettle Point, all the south-eastern shores of this lake are composed of sand dunes and other Post-Tertiary deposits. The upper portion of the Thames and Au Sable rivers are in conspicuously Preglacial beds filled with drift. The Au Sable, after turning northward, continues in a partly re-excavated valley to a point within a mile of Lake Huron, and then turns at an acute angle and runs for a dozen miles southward parallel, and very close, to the lake before emptying into it.

Now, if we look at the large geological map of Canada, it will be seen that the region underlaid by Upper Devonian shales extends south-eastward from Lake Huron, forming a narrow belt across the country to Lake Erie. Dr. Hunt has shown, that in places these shales are four or five hundred feet thick, beneath the drift. On a careful study, it will be seen that these south-western countries of Ontario simply formed a continuation of the valley of Lake Erie to Lake Huron, or *vice versa*. The depth of this valley, or plane, as we have seen, does not exceed 100 feet below the lake level (Erie), except in channels, and generally less than that depth; while the waters in adjacent portions of Lake Erie vary in depth from 30 feet, at the western end, to a maxium depth of 84 feet further eastward, where removed from the mass of modern sediments now being brought down by the western rivers. From these facts, but one conclusion can be drawn, and that is, the deepest western portion of Lake Erie is not silted up to a greater depth than the difference between its soundings and 100 feet; except in channels, such as the Cuyahoga.

From these figures it will be seen that the country including the greater portion of Lake Erie, the south-western counties of Ontario, and the southern portion of Lake Huron formed one nearly uniform plane, in shale-

rocks, which, however, gradually sloped both to the northward and eastward towards the deepest portions of the lakes. From the borings, we see that there were channels, and I think that we are furnished with the data for pointing out where the outlet of Huron formerly flowed, even to a depth sufficiently great to drain the deepest portion of the lake, although filled with some sediment. That portion of the Au Sable flowing northward in an old buried valley, and then turning southward, indicates a portion of the ancient outlet. The channel having been dammed in the Ice Age, has caused the modern river to flow in the capricious manner indicated on the map. This portion of the river reversed, formed an ancient outlet for Lake Huron, and flowed to its south-western angle, then turning eastward, the direction (with gentle curves) was south of eastward across the country to Lake Erie, having Port Stanley on its right, and Vienna on its left bank. It is known that the channel at the former place was 150 feet, and at the latter 200 feet below Lake Erie, and with a sufficient distance between these places to have permitted of a valley four times that depth, even in the Hamilton shales, and underlying Coniferous limestones. At a distance of only a few miles eastward of this line, the Coniferous limestone comes to near the surface of the country, and is exposed by several modern streams. The upper portion of the Thames, the eastern branches of the Au Sable, and other streams belong to Preglacial times with buried channels, were tributaries to this old outlet.

Throughout the south-western counties generally there is a broad belt underlaid by several hundred feet of Devonian rocks (mostly of shale of the Hamilton group), beneath the drift deposits, which cover them to a depth of from 50 to 100 feet.

Two things along this route support the theory that this channel, known to be 200 feet deep (below Lake Erie) and able to drain half of the surface of Lake Huron, was of more gigantic proportions, is the nature of the drift near Port Stanley, and the configurations and soundings of Lake Erie. Near Port Stanley, the drift is piled up much deeper than it is usually found in that section of the country, reaching 150 feet above the lake. From whichever cause (glacier or iceberg), it is just what would be expected along the margin of a valley against which drift-bearing ice would be passing. The other indication is, that if we draw a line from a short distance north of Port Stanley to southward of Vienna (the direction of the valley), it forms a continuation of a nearly direct portion of the present shore, curving slightly [illegible]g point, just off which the deepest portion of the lake is found, and [illegible] which the channel turns, to the Grand river of Canada. It cannot [illegible]ly said that the present configuration of the lake is independent of [illegible]glacial form. Nor can it be said that the lake is generally silted up [illegible]t depths, except in channels, for any such statement is unwarranted [illegible]t, as I have shown from the analogy between the bottom of the [illegible] end of the lake, and the south-western counties, to be improbable.

[illegible]e of Preglacial Rivers. We are now able to construct an approxi[illegible]rue river map from Lake Huron to the eastern end of Lake Ontario.

The streams ran from the north and west of Lake Huron, south-eastward towards Goderich; thence southward, and entered the Au Sable near its northern angle; it turned eastward, near the southern angle of the same river, and with a gentle sweep, having Vienna on the left and Port Stanley on the right bank (receiving the upper-waters of the Au Sable and Thames as tributaries), it passed Long point, flowing near the present Canadian shore, and entering the Grand river (reversed) south of Cayuga; afterwards it passed down the Dundas valley towards north-east, into the basin of Ontario, and then along the foot of the buried Hudson River escarpment to near Oswego.

Along its course, it received, probably, a small stream from near Detroit, the Maumee, Sandusky, Chagrin, Cuyahoga, Grand (of Ohio, and its tributary, the Mahoning), Conneaut, Allegheny, and other rivers from the American States, and afterwards the Genesee and various other streams in its course through the basin of Ontario.

The rate at which this basin was excavated, of course depended on the wear of the limestone rocks after entering the Grand river. But as this was very slow, the softer shaly rocks would gradually be worn down, and the basin of these lakes, in the shaly rocks, across their beds, would be greatly widened, as we see it.

No great pitch in the rivers would be required to occasion a flow of the waters, a very few inches in the mile would suffice. If we observe the deepest portions of Lakes Huron and Ontario, we have a difference in altitude of 360 feet (both being below sea-level) in 400 miles along the route indicated, whilst probably there were lake-expansions along the course, thus causing the fall to be confined to a few places, especially through the Dundas Valley, in the form of a series of rapids after the capping limestones had been removed.

Excavation of Lake Basins. Having seen the course of the Preglacial drainage, let us ask how the broad lake troughs could be excavated. First let us look at Lake Ontario.

The river coming down the Dundas valley flowed originally at near the out-crop of the Niagara limestones, elevated by geological causes long ago. The direction of the stream was parallel to its trend. On the one side, were the soft Cambro-Silurian shales, geographically higher, geologically lower; on the other (southern) side, the Niagara limestones, beneath which were the soft Medina shales, until these were worn away in part. As the shaly rocks were removed the limestones would be undermined, and therefore we had the NIAGARA ESCARPMENT produced. How far these limestones have receded towards the present face and summit of the slope, is a question yet to be decided. As the waters sunk to a lower level a second escarpment was produced (the one noticed at Port Dalhousie, at the present lake level). Afterwards, the Hudson River shales (with some hard rocks) were pierced, whilst yet there were capping Medina shales, forming the surface of the country between the river and the limestone escarpment.

All this presupposes the continent at a higher level (at least between five

and six hundred feet). Prof. Dana points out that the continent, during at least the Mesozoic, if not the Tertiary times, stood at an altitude equal to this measurement, as shown by the soundings at the mouth of the Hudson river, which extends 80 miles seaward; and Prof. Hillgard has shown that the Mississippi also had nearly an equal elevation above that of the present day.

In the sketch of the topography of Lakes Erie and Huron, we have seen that the whole of the latter lake and the south-western half of the former are excavated mostly out of softer rock; and the north-eastern half of Lake Huron is excavated along the junction of harder and softer rocks similar to Lake Ontario.

The rate at which these upper lakes were excavated would depend on the rate of the excavation of the Dundas valley and its extensions through the limestone, at first by a slow abrasion, and the solution of the carbonate of lime by the carbonic acid held in the water, and afterwards by the undermining of the hard rocks on the removal of the Medina shales.

As to Georgian bay and the North channel, these formed independent valleys. That the North channel is excavated out of the Cambro-Silurian shales, along the junction of Niagara limestones on one hand, and the metamorphic rocks on the other, is apparent at a glance; as we see that the Spanish, Mississagua, Thessalon, and other rivers all point in that direction. It has been noticed that the North channel has the same depth as the deepest outlet; and also that the deeper portions of the northern part of Lake Huron are in that direction. An appropriate coincidence is that the strait between Manitoulin and Cockburn islands should be called Mississagua, which was doubtless the ancient outlet of that river; and False De Tour channel that of the Thessalon river.

Again, Georgian bay is scooped out of the soft rocks between the crystalline rocks on the east and the Niagara limestones on the west along the line of junction, similar to the North channel, or to Lake Ontario.

The Indian peninsula is a perfect counterpart to the Niagara escarpment, and the escarpment submerged beneath Lake Ontario. For here the Niagara limestones tower more than 300 feet above Georgian bay, whilst at the foot, but submerged, there is a precipitous descent of 500 feet below the surface of the lake. The deepest outlet into Lake Huron is only about 300 feet. Whether this is filled with drift deposit or not we cannot say. One thing is certain, that a broad depression in the topography of the country extends all the way from the southern end of Georgian bay, including Simcoe, Balsam, Rice, and a multitude of smaller lakes emptying into the bay of Quinté by the Trent river, to Lake Ontario. A great system of drainage did exist along this line. According to Sir William Logan, this trough is deeply filled with drift. Lake Simcoe is 130 feet above Georgian bay, however, and the height of land in the trough to the east of Lake Simcoe is more than 100 feet higher. It may be said that this trough is bounded by a ridge (known as Oak ridge) which is, according to the levels of the Toronto and Nippissing railway, 893 feet above Lake Ontario, and

further westward to about the same height. The country gradually rises from Lake Ontario to this ridge, but on passing the summit, it descends nearly 300 feet. This ridge consists of drift to a considerable depth. I have several profiles across it. Yet there are no indications that the rivers, such as the Nottawasaga and others flowing northward into Georgian bay, formerly flowed in the opposite direction, emptying into Lake Ontario by the Humber.

The evidences are not quite clear whether the Georgian bay always emptied (except when the waters were at a much higher level), by the present outlet, or by that just indicated. But from the soundings I am inclined to favor the present route. It may be stated that the writer is assuming too frequently that the present soundings are some criterions of the original depths. This assumption I hope to prove in a subsequent paper, when treating of the drift-deposits, and feel confident that outside of confined channels of comparatively narrow width, or certain bays, that the evidence adduced, with regard to the western end of Lake Erie, holds still nearer to the truth when applied to the more northern waters. If Georgian bay were so filled with drift we ought not to find the deep escarpment situated so close to Indian peninsula.

One more remark is necessary with regard to Georgian bay and the North channel,—that is concerning the deep bays or fiords. All the conditions for the making of fiords as noticed under Lake Superior exist here. Owen sound, one of the largest of those fiords, is situated at the junction of the Niagara and Hudson River Formations, with a buried channel emptying into it, and now occupied by the small Sydenham river. At any rate the fluviatile origin of this rivulet is unquestionable (although Mr. George J. Hinde asserts that it was made by glacial action), after the study that we have made in the Dundas valley. The buried channel of the Sydenham river is more than half a mile wide at the town of the same name.

Some of the indentations in Manitoulin island were probably formed by rivers flowing across the island, but were closed by drift in portions of their course, thus producing the lakelets and bays. That most of these bays are fiords is apparent, as is also proven by the numerous islands north of Manitoulin islands, the whole being a perfect counterpart of Puget sound, or of the fiords of the Scandinavian peninsula.

Owing to the much greater depth, and other obstacles of the present time, it does not seem at all likely that Lake Huron ever emptied by Georgian bay, excepting possibly at the close of the great floods that made the whole region from Huron to Ontario one body of water, even then the present topography would not favor it.

The Outlet of Lake Ontario. The three great questions, involved in the sub-aërial and fluviatile origin of our three Great Lakes, are, where were the outlets of Lake Ontario, Lake Erie and Lake Huron, at sufficient depths to drain their basins. As shown, the outlet of Lake Erie through the Dundas valley is sufficiently deep to empty the two upper lakes. Also, the outlet

described on previous pages points to every condition necessary to indicate its depth as being sufficiently great to empty Lake Huron, although the actual measurement (on the north-east side of the channel) has only reached to 200 feet below the surface of Lake Erie, with a bottom composed of soft shales. There now remains one other question to be answered, but certainly one of no greater moment than the ancient connection between Lakes Erie and Ontario—the outlet of Lake Ontario.

Dr. Newberry, at times a glacialist, finally appears to advocate the glacial excavation of the lakes after their courses had been determined by river action. Various writers for the last twenty years have referred to the deep buried channel near Lake Onondaga, more than 400 feet below its surface, as indicating the former outlet of Lake Ontario by this route, and down the Mohawk to the Hudson river. This course will not answer, as the Geological Survey of Pennsylvania has shown, for at Little Falls, Herkimer county, the Mohawk flows over metamorphic rock. Various fluvialists refer some buried route by the St. Lawrence. This seems scarcely possible, as that great river flows over hard rocks at various points for 200 miles eastward of Lake Ontario, unless the outlet existed somewhere between Kingston in Canada, and Oswego in New York, and continued in a buried course through crystalline rocks (in part) to eastward of Montreal. The north-eastern portion of Lake Ontario is very shallow, and the deepest channel points to the south-eastward extremity of the lake.

At the present time the writer knows nothing positively of the most probable outlet, as that by the Mohawk will not answer. Yet he will predict that its outlet will be found as certainly as the one between Lakes Erie and Ontario, of which there was no clue, or even suggestion until working up the origin of the Dundas valley. One other route presents itself, but as positive proof is not at hand, I will defer theorizing.

The Geological Survey of Pennsylvania has shown that many of the water courses, emptying southward at the present time, formerly emptied to the northward. In New York, we find most of the small lakes of narrow but long dimensions having their axis in a meridional direction. Also, these waters are generally along some stream flowing northward into Lake Ontario even at the present time. Though the bottoms of these lakes are frequently below the sea level, yet in no case, that I am aware of, are they nearly as deep as Lake Ontario. Doubtless these small lakes were former expansions of the rivers running into Lake Ontario in Preglacial times, and owe to ice, simply, the closing of their outlets by drift.

No local land oscillations apparent. I agree with Mr. Carll that there are no indications of local oscillations in the region of our lower great lakes, at least to account for any changes in the drainage systems. It has been a popular idea that the coast of New England, even at the present time, is sinking. If so, any changes must be very slow, for Mr. Henry Mitchell, of the United States Coast Survey, shows (in appendix 8 of report for 1877), that the whole north-eastern coast of the United States has undergone no change of level during the last hundred years.

Depths of the lakes cannot be accounted for by the relatively higher elevations of northern latitudes. In the first place, Lake Ontario has a bottom very much deeper (below the sea), than even the deepest sounding in Lake Superior. or 500 feet below sea-level.

If a sufficient elevation did occur, it would require to be local, or to extend far to the southward. That it was not local appears from the general dip of rocks in which it lies.

However, any continental elevation or subsidence occasioned by the change of the centre of gravity of the earth, such as that by the great accumulation of ice in the polar regions, would be equal to the elevation or subsidence at the pole multiplied by the sine of the latitude. From this we find that if the elevation at the poles were a thousand feet, the difference between the elevation or subsidence of the northern end of Lake Huron and the Dundas valley, would be equal to only about 40 feet. Even were the ice-cap uniform around the poles, it has never been calculated that it was sufficient to cause a polar difference of 3000 feet of level, which at most would effect the relative levels of the northern end of Lake Huron and the southern latitude of Ontario to no greater extent than 120 feet. Again, it is shown by Prof. Whitney, that no ice-cap occupied north-western America, and by the author of "Fire and Frost" (see Q. J. G. S.), that the ice-belt is only known to have surrounded the region of northern Atlantic. The greatest changes of level by the accumulation or removal of ice would thus be occasioned along the north-eastern margin of America in the region of the Appalachian and Laurentian mountains. If the continent continued high during the Ice Age, the coastal ranges would cut-off most of the moisture, and thus greatly lessen the thickness of any *ice sheet* over the region of the great lakes, if it ever did exist. This is exactly the state of the ice in Grinnell land (Lat. 81° N.). Messrs. Fielden and Rance, observed "the paucity of glaciers, and the non-existence of the ice-cap," (Q. J. G. S., No. 135), and state that no glaciers descend to the level of the sea, as on the Greenland coast or Hall basin.

The idea of the lake basins being greatly effected by oscillations must be abandoned, except so far as the whole area was subject to a more or less uniform change acting proportionably on the eastern and central parts of the continent. Even then, the change was far too little to explain the depths of these waters. Another evidence against the irregular changes of the lake region is that, at the close of the Ice Age we have terraces in Canada a thousand feet or more above the sea, and at various levels all the way to the present surfaces of the waters. Terraces or ridges occur at similar heights in our country, Ohio, New York and elsewhere. In a subsequent paper the writer hopes to show the relation existing between these old beaches, terraces and kames, deposited when our three lakes formed one common body of water. That this water had numerous outlets, as the continent was rising, has been pointed out by the Geological Survey of Ohio. to say nothing of the outlets referred to by the Surveys of Pennsylvania and Canada. At only a comparatively few levels did the waters seem to

linger, as the lower lake region was being desiccated, and therefore we do not find continuous shore lines between many of the beaches; Carll explains this by the waters being frequently lowered by *débâcles*, apparently an adequate reason.

Niagara River. That the Niagara river is Postglacial, at least from the Whirlpool to Queenston, is apparent. It is known that the Niagara river formerly left its present course near the Whirlpool and flowed down the valley of St. David, which is now filled with drift. This valley (through the limestone escarpment) is not so great as the present *cañon*. This buried valley of St. David could only have been produced after the closing of the Dundas valley outlet of the Erie basin, for until then the waters flowed at a very much lower level. Therefore, it seems necessary to regard this channel (not of very great magnitude) as an interglacial outlet for Lake Erie.

The geologists of the Western States point to the Forrest bed as a period of high elevation, preceded by the Erie clay (stratified) and succeeded by the yellow stratified clays or loam, corresponding to the Brown Sangeen clay of Canada, which is unconformable to the underlying Erie clays (or Boulder clay in the upper portion of the Dundas valley). So, for the present, we look upon the old course of the Niagara river as the channel excavated during this warm interglacial period.

Hypothetical Glacier Origin of the Lakes. The writer, having purposely left the hypothesis that the lakes were excavated by glaciers until now, will briefly examine what evidence is existing. One cannot do better than give a summary of what Prof. Whitney (in Climatic Changes) says with regard to the erosive power of ice. "Ice *per se* has no erosive power." Glaciers are not frozen to their beds. Ice permeated with water acts as a flexible body and can flow accordingly. In neither the extinct glacier regions of California nor in the shrunken glaciers of the Alps will it be found that ice scoops out channels with vertical sides as water does.

"No change of form can be observed at the former line of ice. Aside from the morainic accumulations, there is nothing to prove the former existence of the glacier, except the smooth, polished or rounded surfaces of the rocks, which have no more to do with the general outline of the cross-section of the valley than the marks of the cabinet-maker's sandpaper have to do with the shape and size of the article of furniture whose face he has gone over with that material."

The most important work of a glacier is the scratching and grooving of surfaces. This may, however, be done by dry rubbing, and therefore isolated scratched stones or patches are no evidence. The underlying rock surfaces may lose their sharpness, owing to contained detritus in the ice, and become rounded. The ground moraine is neither characteristic nor important. There is but little detrital material beneath Alpine glaciers, and this is the result of water more than ice. The only characteristics of ice action are striation and polishing. All floating ice shod with stones frozen in them will scratch surfaces over which they rub. The only gla-

cial lakes that are formed are those where pre-existing valleys have been closed by morainic matter, but the waters will soon reöpen these dams by running over them.

Such are the deductions of the late Director of the Geological Survey of California, a man who has had opportunities for studying the action of glaciers better than most geologists in America. So far, Prof. Whitney's investigations are applicable to our great lakes, though I do not agree with him that some of them occupy geological valleys (unless possibly Lake Superior).

Mr. George. J. Hinde, F. G. S., one of the few geologists who has written from a Canadian standpoint, is an uncompromising glacialist. Because he has seen scratches in the north-eastern end of Lake Ontario, and also others in a similar direction at the western end of the lake, therefore he asserts that Lake Ontario was excavated by a glacier. Dr. Newberry accepts his statement as proof, but considers that a Preglacial valley determined the direction of the continental glacier.

Mr. Hinde also asserts his belief that the buried valley of the Niagara river (by way of St. David's) as also the valleys at Dundas and Owen sound, are of glacier origin. We have proved in this paper incontrovertibly that the Dundas valley is a buried river channel. Also it has been seen that Owen Sound and the St. David's valley are both beds of Preglacial or Interglacial rivers.

Let us analyze the direction of the ice scratches in the neighborhood of the western end of Lake Ontario. I have not seen any (out of very many sets), that is parallel with the axis of either the Dundas valley (except *possibly* one polished surface in the valley), or the axis of the lake, but always at considerable angles. In the region of Kingston, the prevailing scratches are S. 45° W. (Bell) and some others at S. 85° W, neither of which directions are parallel with the axis of the lake. Granted that Mr. Hinde observed scratches that were parallel with the axis of the lake, they of necessity would have been at an angle with the submerged escarpment. If any glacier could have scooped out the basins of Lake Ontario, it left the summit edges of the Niagara escarpment as sharp as possible, and not planed off. Also, if it excavated the deep trough of the lake, it left a summit of soft Medina shales over the harder Hudson River rocks of the submerged escarpment, beneath which are Utica shales. From Dundas to the Georgian bay the face of the escarpment (Niagara) is less abrupt, but even here, there has not been left more than 50 feet of drift at its foot, and this mostly, if not altogether, stratified (excepting in channels now buried).

The observations of Prof. Prof. H. Y. Hind, on the coast of Labrador, are here interesting. He has shown that *pan ice*, at the present time, is polishing the sides of cliffs, and has been continuing its action whilst the coast has been rising several hundred feet. Even under the ledges of overhanging rocks the action is now going on (a phenomenon which, if in the lake region, would be attributed to glaciers). Also, he has seen boulder clay being formed at the present time by the action of *pan ice* (frozen sea-

water). This, with a thickness of eight or ten feet gets piled up by the action of waves and wind, and consequently in the bays of the coast of Labrador it polishes rock bottoms to a depth of fifteen feet or more, below the surface of the water, and grinds off rough surfaces. I have frequently seen, myself, in northern regions, high boulders transported by the ice to which they were frozen in the margin of small lakes.

From what has been written, it seems to the writer that the glacial origin of Lake Ontario does not rest on a single basis further than that ice scratchings (producible by either glaciers or icebergs, neither of which need be great erosive agents) are seen at various places about Lake Ontario, both above and below the water-level. The remarks applied to Lake Ontario hold good for the other lakes. The description of their topography strengthens the proofs that their origin cannot be accounted for by glaciers, because we find the islands at the western end of Lake Erie, or northern end of Lake Huron, polished and striated.

Before closing, permit me to thank those railway companies which have kindly furnished me with many levels. But in doing this, I may state that it is my purpose to make further requests and hope to do for Ontario, what the Pennsylvania Survey has done, in collecting all levels that bear on the topography of my native Province, in order to make a more complete study of the Preglacial drainage of the great lake region.

Geological Section at St. Mary's, Elk County, Pennsylvania. By Charles A. Ashburner, M. S.

(*Read before the American Philosophical Society, March* 18, 1881.)

Introduction. Probably no locality within the Bituminous Coal Fields of Pennsylvania has had so many and such conflicting reports published on its coal geology as the counties of McKean and Elk. Had these reports been made with the desire of merely collecting facts, and of showing their true correlation, we would no doubt long before now have reached the truth in regard to the systematic geology of the coal measures; unfortunately for science, for the geologist and the capitalist, most of the individual investigators have been biassed and prejudiced in their studies, by a natural desire to find favorable facts, from which to deduce conclusions enhancing property values. In many cases true facts have been presented, but as a rule they have not been sufficiently numerous from which to draw conclusions of a correctness beyond question or doubt.

As we look back over the varied history of this region during the past twenty years, examine the reports which have been made, both privately and publicly, note the mineral development of the region, consider the results attained, estimate the profit and loss in money value, and count the benefits accruing to the land owner, the county and Commonwealth, the picture presented is unsatisfactory. The steady, permanent develop-

ment of the coal fields has been misdirected, and consequently retarded. Investments have too often met with disappointment, followed by failures.

A geologist cannot manufacture good coal beds or purify poor ones; and he steps beyond his professional bounds as a practical geologist when he attempts aught else than the discovery of facts and their true economical interpretation.

If there are any advantages to property holders to be derived from too favorable and rose-colored reports, they are certainly only immediate and are insignificant in comparison with the more permanent ones resulting from true, unbiassed and less favorable reports.

I have prefaced my paper with these remarks, because the results of my examinations in the counties mentioned have two direct and important but quite independent bearings; one is purely commercial in its aspects, as it interests and affects the land owner and coal operator; the other belongs to the province of pure geology concerning only the geological investigator and student.

It is my present purpose to merely describe a new interpretation which I have made of the stratification in the vicinity of St. Mary's, Elk County, and to indicate its bearing upon the systematic geology of other portions of the district.

Statement.—The detail geology of McKean has already been published in report R of the Geological Survey; that of Elk will be found in connection with the geology of Cameron and Forest in the forthcoming report RR.

The local geologists of Elk County generally consider the coal measures in the vicinity of St. Mary's to be low in the series; whereas I make them to include the representatives of the Lower Freeport, Kittaning, Clarion and Mercer (or Alton) coal groups.

I fully realize the fact that I am making a statement which is directly opposed to the general views held in regard to the nomenclature of the St. Mary's coal beds. But the most important and difficult problem which I have had to deal with, has been the identification of the coal rocks; and the conclusions which are now advanced have only been reached after a careful detail study of the coal basins of McKean, Cameron, Elk and Forest counties. A great many observations have been made in adjoining counties in order to confirm the work, and connect it with that done by other survey assistants in adjoining fields.

The fact that a rock section contains the representatives of certain well known and established groups, does not necessarily imply that each group has a well defined representation of the individual beds which characterize it at the place of its best development. The special features which have determined the naming of the sub-groups of the coal measures, at their typical locality, may be wanting at many places where the occurrence of the group itself can alone be determined by a comparative study of the entire formation.

From the fact of the St. Mary's section containing the rocks of four of the principal groups of the Lower Productive coal measures in the State,

the natural inference would be that a number of valuable workable beds should be found here, out of the eight beds which these groups generally embrace, and which have proved so productive in other portions of Pennsylvania. The fact is, however, that at St. Mary's only one coal bed has as yet been found* of sufficient purity and thickness† to be profitably mined *over any considerable area*. This bed is the Dagus or Lower Kittanning coal bed.

But besides this bed the St. Mary's section contains representatives of the Upper and Middle Kittanning, the Clarion and Mercer coal beds; and the ground at the Patton Hill near the west mine of the St. Mary's Coal Company is high enough to contain a very small area of the Freeport Lower coal, although it has not been discovered.

The following is a general section of the coal measures in the vicinity of St. Mary's, compiled from facts obtained within a radius of one and a half miles of the Philadelphia and Erie railroad station. For the sake of completeness I have added to this section the record of the drill hole of the St. Mary's Oil Company, making in all nearly a half mile of vertical thickness of rocks whose character is actually known:

Elk County Section; at St. Mary's.

1.	Gray sandstone, shale and slate	67
2.	Coal, *Kittanning Upper*	3′
3.	Sandy shale and slate	33′
4.	Coal, *Kittanning Middle*	1′ 6″
5.	Sandstone and shale	55′
6.	Coal, *Dagus, Kittanning Lower*	3′
7.	Fireclay‡	3′
8.	Shale	17′
9.	Coal	1′ 4″
10.	Sandstone and shale	10′
11.	Limestone and shale, *Clermont, Ferriferous*	10′
12.	Shale	13′
13.	Coal	5″
14.	Shale	16′
15.	Coal, *Clermont, Clarion*	2′
16.	Sandstone and shale, JOHNSON RUN S. S.	32′
17.	Coal, *Alton Upper*	2′ 7″
18.	Shale	18′

*The Clermont or Clarion bed has been worked to a limited extent on the Monastery lands east of Silver creek, about three-quarters of a mile northwest of the St. Mary's railroad station.

†The degree of purity and extent of thickness necessary to constitute a workable, marketable coal bed, are purely arbitrary, and their values are dependent upon commercial questions.

‡A fireclay bed invariably forms the floor of all our bituminous coal seams. They have not been noted in the section except where their thickness has been determined; in most cases they have been included in the rock interval beneath each coal bed.

19.	Coal, *Alton Lower*	8′		
20.	Sandstone, KINZUA CREEK S. S.	45′		
21.	Shale and Coal	10′		
22.	Sandstone and conglomerate, OLEAN CONGLOMERATE	50′		
23.	Slate, sometimes containing a coal bed 2′ thick	10′		
	Total	406′		
24.	Grit, clay and gravel (top of St. Mary's drill hole)	18′	to	18′
25.	Sand	18′	"	50′
26.	Interval	45′	"	95′
27.	Sand	25′	"	120′
28.	Interval	140′	"	260′
29.	Sand	16′	"	276′
30.	Interval	124′	"	400′
31.	Sand	20′	"	420′
32.	Interval	205′	"	625′
33.	Red shale, sandstone and slate	335′	"	960′
34.	Interval	12′	"	972′
35.	Sand	49′	"	1021′
36.	Interval	369′	"	1390′
37.	Red sandstone	25′	"	1415′
38.	Interval	35′	"	1450′
39.	Reddish rock	5′±	"	1455′
40.	Interval	215′	"	1670′
41.	Sand	44′	"	1714′
42.	Gray and black slate, containing shells and streaks of red	286′	"	2000′
43.	Fine bluish-white sand	10′	"	2010′

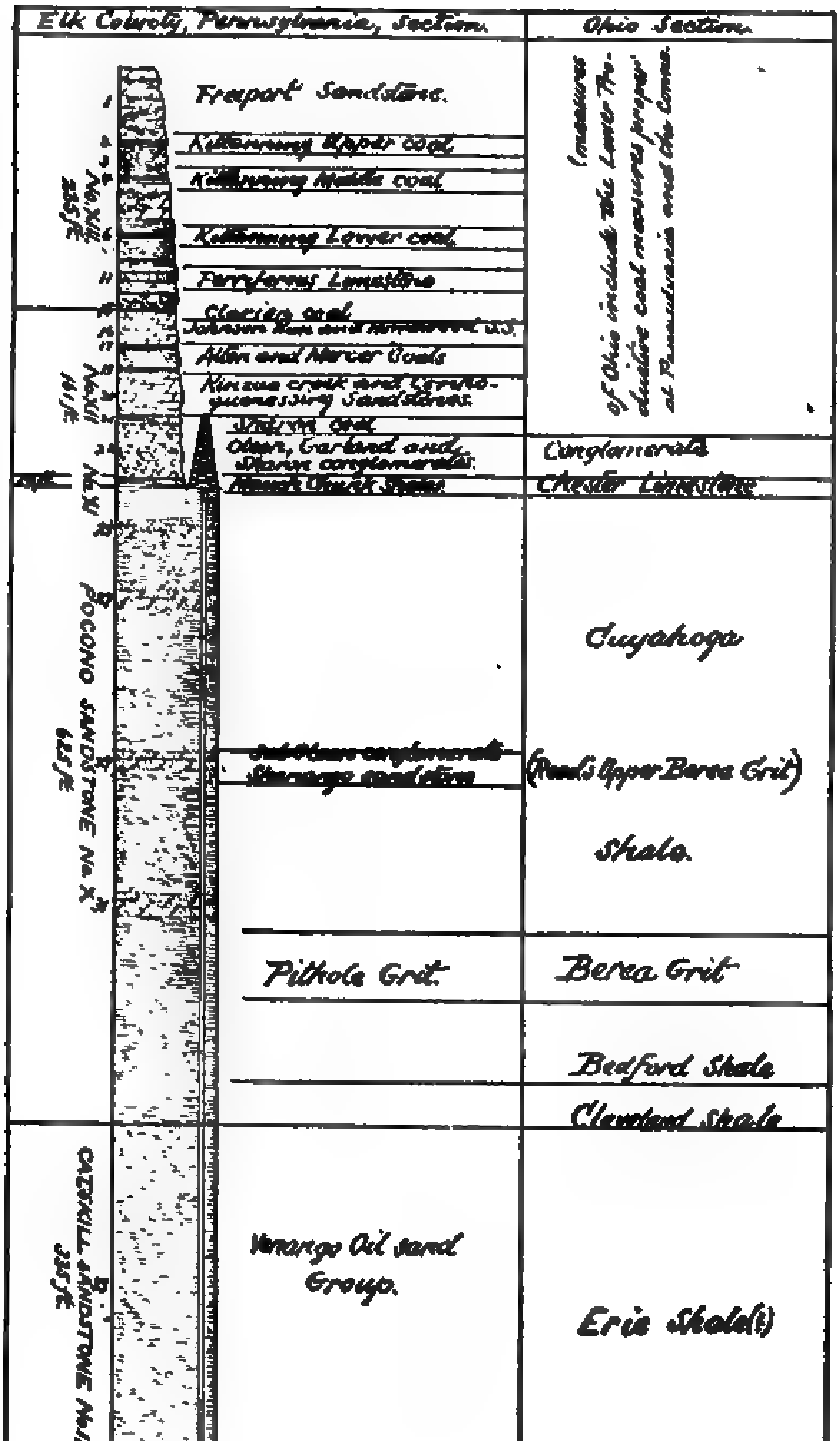
The record of the well is given just as it was reported by Mr. W. W. Ames, who had copied it from the driller's book. The undescribed intervals contained generally gray slate.

A small *gas vein* was struck at a depth of 550 feet; at 972 feet a very much larger one was found. At a depth of 450 feet and 1020 feet salt water was encountered. The geological horizon of the *Bradford Oil sand* is at least 250 feet below the bottom of the St. Mary's test well.

The section may be grouped into formations as follows:

CARBONIFEROUS AGE.

XIII.	Lower productive Coal Measures (1 to 15 incl.)	235′
XII.	Pottsville conglomerate (16 to 22 incl.)	161′
XI.	Mauch Chunk shale (23)	10′
X.	Pocono shales and sandstones (24 to 32 incl.)	625′
	Total	1031′


Elk County, Pennsylvania, Section.
Ohio Section.
Freeport Sandstone.
Kittanning Upper coal
Kittanning Middle coal
Kittanning Lower coal
Ferriferous Limestone
Clarion coal
Allen and Mercer Coals
Olean, Garland and Sharon conglomerates.
Pithole Grit.
Venango Oil sand Group.
POCONO SANDSTONE No. X
CATSKILL SANDSTONE No. IX
Conglomerate
Chester Limestone
Cuyahoga
Shale.
Berea Grit
Bedford Shale
Cleveland Shale
Erie Shale(?)

DEVONIAN AGE.*

IX.	Catskill sandstone and shale (33)...............	335′
VIII.	Chemung shale and sandstone (34 to 48 incl.)...	1050′+
	Total..	1385′
	Total of known rocks.........................	2416′

Lower Productive Coal Measures.

This group, which is 235 feet thick at St. Mary's, contains only one coal bed which has proved productive to any great extent.

The rocks of interval No. 1 of the section form the top of the Patton Hill and include the FREEPORT SANDSTONE and possibly the *Freeport limestone* and *Freeport Lower coal bed*, although neither of the latter have been discovered. Ten miles south-west of St. Mary's the *Freeport limestone* is only 40 feet above the Kittanning Upper coal, and the Freeport Lower coal is only 50 feet above the same bed; at St. Mary's the top of the hill is 67 feet above the latter. The total absence of the Freeport coal and limestone here, argues either a disappearance of the beds to the north-east or a considerable thickening of the Freeport sandstone in the same direction.

The *Kittanning Upper coal* (stratum 2) is reported to have been found in a well dug near Patton's house. This is the only place in the township where it has been found. The bed is said to be 3 feet thick, but has never been thoroughly tested.

The *Johnstown cement bed* which occurs between the Kittanning Upper and Middle coals has not been found; it is, however, well defined in the sections of Fox and Horton townships, to the south-west.

The *Kittanninny's Middle coal* (stratum 4), has been found on the Cascade Mining Company's tract (Kaul and Hall). It is only 18 inches thick and not workable.

The *Dagus or Kittanning Lower bed* (stratum 6), is the principal and most important coal. It has been worked in the mines of the St. Mary's Coal Company, Cascade mines, Tannerdale mines, Keystone mines and has been opened and tested on a number of other properties.

This bed is without doubt the same as that which is mined by the North-western Mining and Exchange Company near Centerville, and which is locally called "C" bed and the "Gas Vein," which has been opened by Genl. Kane on the Roberts lot in Jones township.

Objections.—Local geologists have always considered the St. Mary's bed to be very much inferior to these two latter seams. This conclusion, although unquestionably false, has been based upon three very significant facts:

First. The St. Mary's bed is found at a very much lower level than either the "Gas Vein" or the "C" bed at Centerville.

Second. No limestone is found under the St. Mary's bed to correspond

* The Devonian Age here is made to include the Catskill formation, in order to agree with the accepted division of the Palæozoic Period in the Penna. Survey reports. I believe, however, that the Catskill rocks are of Carboniferous age.

with that formed at Genl. Kane's quarry 40 feet under the "gas vein" or 40 feet below the "C" bed on Toby creek.

Third. The St. Mary's bed is rustier in appearance and does not produce as rich a coal as either the "gas vein" or "C" bed, at the same time the floor and roof of the three beds differ materially in the three localities.

Although these are pointed and pertinent objections against the indentity of the three beds, I have not found any facts to sustain them; to the contrary, the weight of evidence, when carefully considered, is directly in support of the conclusion, which after four years of field work I have no hesitancy in asserting, that the coal bed mined by the St. Mary's Coal Company, by the North-Western Mining and Exchange Company and which has been opened on the Roberts lot above the limestone, is in every case the representative of the Lower Kittanning coal bed.

Demonstration.—It is impossible to give as many facts to prove my position in this paper as I shall present in the published volume of the survey, but I think I can answer these objections in a way satisfactory both to myself and reader.

1. The following elevations above tide will show the relative heights of the bed in the three localities:

At St. Mary's it is....................................1775 feet.
*Near Centerville it is..............................1835 " †
On the Roberts lot it is..............................1975 "

These three places are in three different and quite independent coal basins, and it would be unnatural that there should be any fixed or definite relationship existing between their heights. The Roberts lot is in the Fifth Bituminous coal basin and this is separated by a high, broad anticlinal, running in a north-east and north-west direction, east of Ridgway, from the Fourth Basin in which St. Mary's and Centerville are located. The mines at these two latter places are *in different sub-divisions of one main synclinal.*

I think every one acquainted with the facts in the vicinity of St. Mary's and Centerville, will recognize the fact that between the east and west mines of the St. Mary's Coal Company there is a synclinal axis having a north-east and south-west direction, and that the head waters of Toby creek near the mine marks nearly the position of another synclinal axis; that these two axes are not continuations of one another would be evident to any one studying the facts carefully on the ground.

I am aware that this latter conclusion will be vigorously opposed, but I believe it cannot be absolutely denied until more *facts* are brought forward to oppose it, than I have to confirm it.

2. In regard to the *limestones* it seems to be quite certain that the limestones and shales composing an interval of 30 feet, 40 feet below the "gas

* Head of Toby creek. The same coal is 1922 feet, ¼ mile north of the Centerville store.

† On a profile just received from Mr. Oliver W. Barnes, the approximate elevation of the coal bed at the mine of the North-Western Mining and Exchange Company is stated to be 1779 feet. The elevation here given (1835') is based upon the elevation of the road at Centerville, in front of McCauley's store, which, according to Dr. C. R. Earley, is 1963 feet above tide.

vein" on the Roberts lot; the limestone which is 6 feet thick and 40 feet below the "C" bed at Centerville, and the limestone bands and shales 10 feet thick exposed in a railroad cutting one mile east of the coal shutes of the St. Mary's Coal Company, and 31 feet below the St. Mary's bed, are all representations of the *Ferriferous limestone.*

This conclusion is based upon a comparative study of all the individual members of the rock sections in the three localities. On account of the bad exposures in the Johnson run basin in the vicinity of the Roberts lot and along Toby creek, and on account of the limestone in the two places lying low in the valleys, it has always been difficult to determine the rock thicknesses below the limestone. This fact has resulted in each case, of placing the limestone too high in the measures, and consequently an error in the identification.

It is generally believed that no limestone occurs at St. Mary's. On careful search an outcrop of the bed may be found on a hill north-west of the railroad station. I have been told upon good authority that pieces of stone have been gathered here which have been burned into lime. This limestone is the same bed which is shown in Rogers' section (Vol. II, p. 522, Final Report First Survey).

It has been reported that the limestone which was located by the assistants of the First Survey was planted by persons having coal interests, with the view of deception. Neither Prof. Rogers nor his assistants were deceived; the limestone which is placed in the section already noticed occupies exactly the same relative position as that in the accompanying section.

The *Ferriferous limestone* has a variable character throughout Western Pennsylvania, so that a difference in the quality and thickness of the beds in the three localities named do not argue against their identity.

3. The character of the *Dagus* or *Kittanning Lower bed*, together with its flooring and roofing strata, are found to vary considerably within the immediate vicinity of St. Mary's, where its identity may be determined by the engineer's level alone.

The following analyses, made by Mr. A. S. McCreath, show marked variations in the chemical constitution of the coal:

	a.	*b.*	*c.*	*d.*
Water	.990	1.190	1.050	.990
Volatile matter	38.355	33.990	39.295	40.585
Fixed carbon	52.826	50.990	48.001	49.416
Sulphur	2.044	3.118	3.324	3.369
Ash	5.785	10.710	8.330	5.640
	100.000	100.000	100.000	100.000
Color of ash	reddish gray.	lilac.	pink.	pink.
Coke per cent	60.655	64.820	59.655	58 425
Fuel ratio	1:1.37	1:1.50	1:1.22	1:1.22

a. Tannerdale mine, worked by St. Mary's Coal Company, two miles

north-east of St. Mary's. Average thickness of coal 3 feet 6 inches. Coal, dull black, more or less coated with iron oxide; partings of pyrites in very minute crystals partly decomposed.

b. East mine, St. Mary's Coal Company. Average thickness of coal 3 feet 2 inches. Coal, dull black, brittle, iridescent, numerous partings of pyrites and slaty coal.

c. West mine, St. Mary's Coal Company. Average thickness of coal 3 feet. Coal, dull black, more or less stained with iron oxide, rather friable and contains numerous partings of pyrites and slaty coal.

d. Cascade mine, Kaul and Hall. Average thickness of coal 3′ 8″.

Coal, deep black, lustrous and coated with silt; contains considerable pyrites, which is partially decomposed.

For the sake of comparison I have added the analyses of the Roberts lot coal and the coal of the North-Western Mining and Exchange Company at Centerville, and of the *Clermont, Clarion* bed on the Monastery lands:

	e.	*f*.	*g*.
Water	2.460	1.080	.870
Volatile matter	37.990	38.455	37.890
Fixed carbon	52.816	53.190	52.657
Sulphur	.814	1.975	.838
Ash	5.920	5.300	7.745
	100.000	100.000	100.000
Color of ash	yellow.	gray pink tint.	cream.
Coke per cent	59.550	60.465	61.240
Fuel ratio	1 : 1.39	1 : 1.38	1 : 1.39

e. Hoyt opening on "gas vein" Roberts' lot, Jones township. Coal has a dull black luster; cannelly structure; laminæ indistinct; fracture generally irregular, but with a tendency to a cubical.

f. "C mine" North-Western Mining and Exchange Company. Average thickness of coal 3 feet 6 inches. Coal, deep black, lustrous, brittle; shows numerous thin partings of pyrites in minute crystals, partially decomposed.

g. Silver creek mine on Clermont bed, Monastery lands, D. Eldridge operator. Average thickness of coal 3 feet. Coal, deep black, lustrous, brittle, no crystals of pyrites observed. By a comparison of these analyses it will be found that greater differences exist in the composition of the bed in the immediate vicinity of St. Mary's, than between the coal at Tannerdale, Centerville and Roberts' lot, or between the coal from the bed at any one of these three places, and that taken from the Silver creek mine on the Monastery lands.

There is no characteristic *belonging* to the Kittaning Lower coal bed, which may serve as a means for its identification. Where the greatest differences in the composition of the bed exist, as at St. Mary's, the coal can be easily traced and located in the series, by observations made on the

topography; where the composition of the bed is most similar, as at Tannerdale, Roberts' lot and St. Mary's, it requires all the skill and judgment of a trained geologist to determine their geological relationship.

In the east mine of St. Mary's Coal Company the roof is found to change suddenly from a black slate to a hard, massive sandstone. The same thing is reported to have occurred in the now abandoned Keystone mine.

Conclusion.—In view of these facts as regards the variation of the composition of the Dagus or Kittanning Lower coal bed and the changes which are liable to occur in the associated strata within a small area, similar differences at localities so far removed from one another as St. Mary's, Centerville and Roberts' lot, can certainly have but little weight in determining the relative position of the beds.

The best and most reliable means of ascertaining the connection existing between distant rock sections is, by making *a comparative study of sections in their entirety.* A marked similarity will oftentimes be found to exist between the general structure of each section, even where no persistency of character is found to exist between the minor features.

Clermont Group.—The *Clermont** or *Ferriferous limestone* has a distinct and well recognized representative in the vicinity of St. Mary's. The horizon of the limestone is 80 feet above the *Clermont* or *Clarion* coal bed. As has been said, pieces of the stone were found along its outcropping level on the hill north-west of the town.

In a railroad cutting two miles north-east of St. Mary's station, and extending from mile-post 130 to 130+500 feet, is found exposed the representative of the Ferriferous limestone. It consists of gray and black shale and slate containing bands a few inches thick of limestone and lime balls, heavily charged with iron. No limestone has ever been found in the Fourth Basin north-east of St. Mary's.

The *Clermont* or *Clarion coal bed* (stratum 15), marks the top of the Carboniferous or POTTSVILLE CONGLOMERATE, No. XII. This is the position usually occupied by the Brookville coal bed, but I failed to recognize its representative any where within my district of four counties. The best illustrations and discussion of the variations of the Clarion and Brookville coal beds and of the underlying Homewood or Kinzua creek sandstone may be found in the Clarion county report by Dr. H. Martyn Chance.

Alton Group.—The position, extent of area and character of the Clermont and Alton group coals is a matter of considerable importance to the coal interests centered about St. Mary's. No geological report can settle the question in a practical way. That the coal beds should exist, *if the strata were perfectly regular*, I can positively assert; that they do not exist at every point, has been practically proven. The strata are liable to change, and it must be left to explorations of the drift, the drill-hole and the shaft, to test practically the economical value of these coal beds.

* *Clermont* is a local geographical name which I gave to this limestone in McKean and Elk counties, its use was only adopted provisionally until its identity with the *Ferriferous limestone* of Western Pennsylvania should have been placed beyond a doubt.

The irregularities which are so characteristic of the Alton group coals in McKean county* belong not only to the Alton coals, but also to the Clermont coal at St. Mary's. Although very little encouragement can be extended the coal operator or land owner as to the value of these beds, it would be presumptuous for the geologist to condemn the territory which by a surface instrumental survey should be found to be high enough to contain these coal seams. The area under which the coal beds *might be found* is very great.

On the Monastery lands, on the east side of Silver creek, the Clermont bed has been extensively worked and has produced a good quality of coal. The coal has been explored for on the St. Mary's Coal Company's tract, but has never been found.

The Alton beds (strata Nos. 17 and 19), have been found on the Monastery lands, on the Keystone and Tannerdale tracts. The interval between the two beds varies from 14 to 28 feet. Each bed is generally composed of two distinct benches of coal, with a stratum of slate or clay between them.

The *Alton* group, which represents the same series of strata as the *Mercer* coal group, sometimes contains three coal beds, as in central McKean, but as a rule it rarely embraces more than two coal beds, as is found to be the case generally throughout Elk.

Resembling in many of its features the Mercer group of Lawrence and Mercer counties, the Alton group differs essentially from the Mercer in containing no beds to represent the Mercer limestones; for no calcareous strata have been seen in it, in McKean, Cameron, Elk or Forest counties.

The shales and clays between the Alton coals frequently contain nodules of iron carbonate ore. The iron is, however, never regularly stratified. These beds represent the Mercer iron shales along the Pennsylvania-Ohio line.

No. XII.—The Pottsville or Carboniferous conglomerate (Millstone grit of the English geologists), does not consist of one solid bed of conglomerate, but is composed of a series of rocks made up of conglomerates, sandstones, shales, slates, fireclays and coal beds, divided as follows:

Johnson run and Homewood sandstone	32′
Alton and Mercer coal groups	34′
Kinzua creek and Connoquenessing sandstones	45′
Marshburg Upper and Sharon coal interval	10′
Olean, Garland and Sharon conglomerates, Second mountain sand and Ohio conglomerate	50′
Total	161′

The first name given for each subdivision is that which was provisionally adopted in McKean county, the latter names are those which are better known along the Ohio-Pennsylvania State line.

The individual members of the Pottsville conglomerate have been fully described in the Survey reports to which the reader is referred.

* Geological Survey, Report R, page 58.

The name *Lower Productive coal measures*, still in use for the sake of convenience, is a purely local and relative term, without classical value. When first applied by the First Geological Survey of Pennsylvania, it was intended to include the workable productive coal beds of Western Pennsylvania with their associated strata lying between the coal measure conglomerate and the Mahoning sandstone, or base of the Barren measures. At that time the conglomerate was supposed to be one solid bed of rock, subject only to local variations in thickness and in the proportion of sandstone to conglomerate.

But within the past five years a study of it has shown it to be a variable group of hard and soft strata, including workable coal beds with their under clays. It therefore properly forms a part of the Lower Productive Coal Measure Series: and only thus can the parallelism of the Ohio and Pennsylvania sections be made good.

Stated Meeting, April 1, 1881.

Present, 10 members.

Vice-President, Mr. E. K. Price, in the Chair.

Sig. Damiano Muoni signified his acceptance of membership, by letter dated Milan, January 20, 1881.

Mr. Joseph J. Lewis, accepted membership, by letter dated West Chester, March 24, 1881.

Letters acknowledging the receipt of Proceedings were received from the Philosophical Society at Glasgow, March 9 (106); the Fondation Teyler, Harlem, 3 Mars (105, 106 and List); the American Ethnological Society, New York, March 24 (107); and J. H. C. Coffin, Washington (107).

Letters of envoy were received from the Geological Survey of Pennsylvania, Harrisburg, March 29, and Dr. Peters, Kiel, February 23, 1881.

Dr. Nolan informed the Society by letter that a box of Indian relics had been sent to the care of the Academy of Natural Sciences, by Mrs. Haldeman, for the American Philosophical Society. On motion these were ordered to be deposited in the Academy's museum, and Dr. Horn was appointed to verify the list.

Donations for the library were reported from the Asiatic

Society of Japan; the Academies at St. Petersburg, Berlin, Rome and Philadelphia; the Bureau of Statistics of Sweden; the Zoologischer Anzeiger; Frankfurt Geographical and Statistical Association; Bordeaux Commercial Geographical Society; MM. Delesse and Lapparent, and Revue Politique of Paris; British Association, Royal Astronomical Society, Chemists' Journal and Nature; Nova Scotia Institute, Canadian Naturalist, Prof. Ed. C. Pickering, Hon. Robert C. Winthrop; the Middletown Scientific Association; the American Journal of Science; Mr. C. B. Dudley; Mr. H. C. Lewis; the Second Geological Survey of Pennsylvania, and the Johns Hopkins University.

A box of Indian flints for the cabinet sent from Chicques, Lancaster County, Pa., by Mrs. Haldeman, was reported in the care of the Academy of Natural Sciences, Philadelphia.

Rhætic flora. The Secretary reported that he had received letters from Prof. W. M. Fontaine, of the University of Virginia, dated Charlottesville, February 21st and March 29th, respecting the publication in the Transactions of a Memoir on the Rhætic flora, and on the formation to which they belong, in Virginia and North Carolina; about 340 pp. MS. with 32 4to plates, the figures closely placed, and nearly all in outline, with only indispensable details.

Besides the descriptions of plants, the author gives "a pretty full account of the geology of the Mesozoic of Virginia, with an explanation of its peculiar features." He has "a very large collection of fine plants. Many of them are new, some exceedingly fine; and all of them, whether already described or as yet undescribed, much more perfect than any hitherto found." "The collection is a pretty fair representation of the flora of the older Mesozoic, and will throw light on the Mesozoic of North Carolina and Pennsylvania."

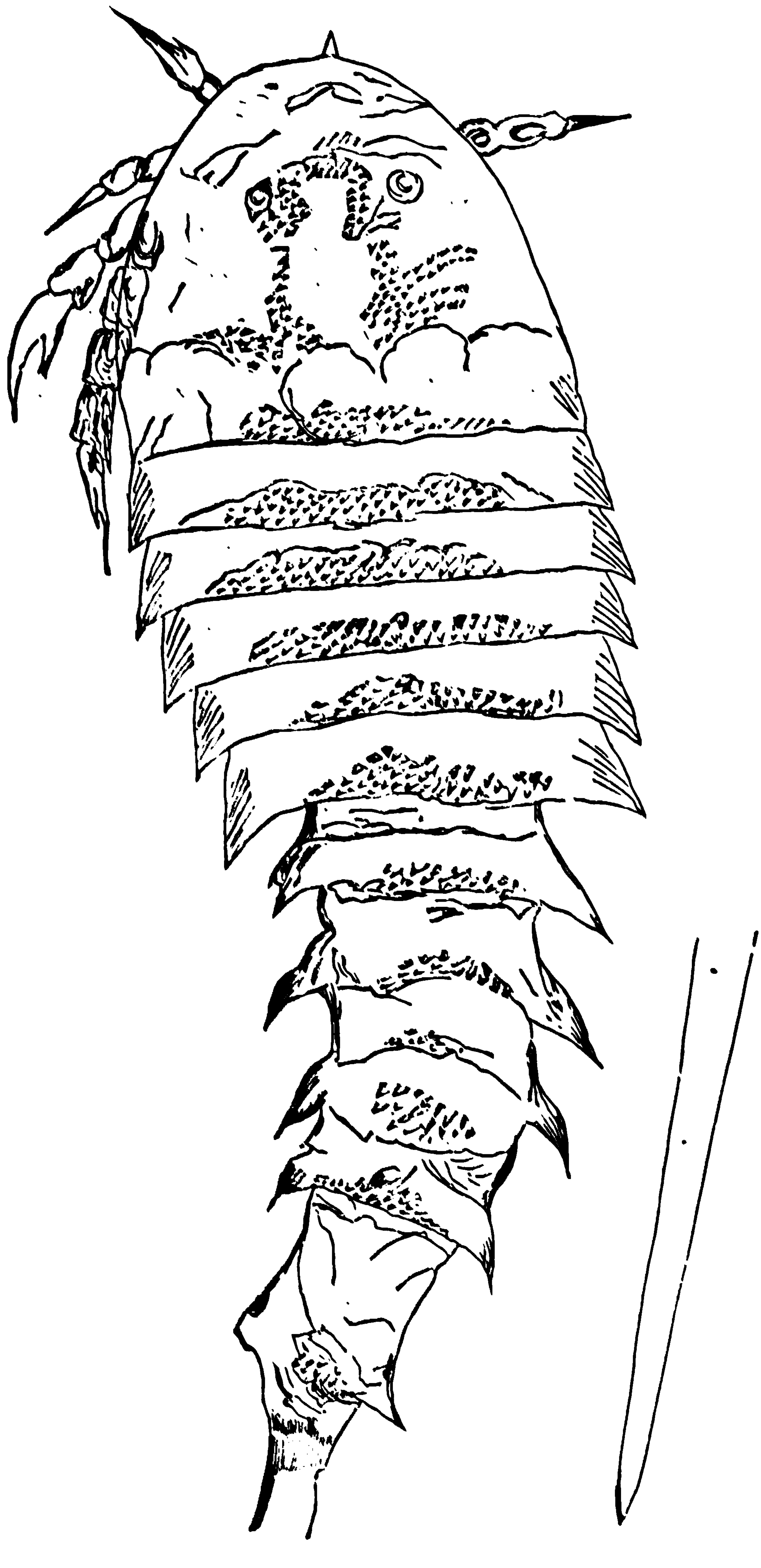
Saltville fault. The Secretary communicated the following notes by Prof. Fontaine, made in the same letters, upon the views of Mr. H. C. Lewis respecting the structure of the Saltville valley in Southern Virginia, published in the Proceedings No. 107, page 155.

Mr. Fontaine points out that the little salt and gypsum bearing valley of Saltville cannot be "eroded along an anticlinal of Lower Silurian limestones," because the south-east wall hills only are of that age, while the north-west wall hills are of Umbral (Mauch Chunk, Subcarboniferous) age. He was the first to find in the limestones on that side of the valley an abundance of Umbral fossils, in the highly fossiliferous shale beds intercallated between the massive limestones. The species are the same found in the Umbral near Lewisburg, West Virginia. The Magnesian (Lower Silurian) limestone strata, bounding the valley on the south-east, show no trace of fossils.

The physical aspects of the two formations also differ. Beds of shale and limestone alternate in the hills N. W. of the valleys; and some of the limestone is cherty, and some of the shales are red. But the S. E. hills contain only solid limestone strata. Those on the N. W. side have a more rounded topography.

It is, however, quite true that the stratification is in opposite S. E. and N. W. directions; gentle to the S. E. and much steeper to the N. W. The structure is therefore anticlinal. But there must be a considerable fault along the axis of the anticlinal, and this fault must run along the south-east edge of the little valley.

The explanation is then simple. The Umbral limestone ridge is a synclinal; and the red shale formation comes up on both sides of it,—with north-west dips in the little valley,—and with south-east dips in the valley of the Holston river, at the foot of the mountain, as shown above.



EURYPTERUS FROM DARLINGTON SHALES, PENN.

Amer. Philos. Soc. Proc., Vol. XIX, p. 152, April 1, 1881.

A reference to the place of the Michigan Salt group in the Palæozoic series makes the presence of salt here easily understood. The horizon seems to be salt-bearing in other places in Southern Virginia. There is a salt ooze near Max Meadows, at about this geological horizon.

The Secretary suggested, in addition, that the underlying Vespertine (Pocono) sandstone is a great salt producing formation in the Ohio river up-country. That the gypsum is an acid reaction upon the eroded outcrops of the limestone he showed in Proceedings A. P. S. Vol. IX. p. 84, 1862.

Mr. J. F. Mansfield of Cannelton, Beaver county, Pa., communicated by letter, dated House of Representatives, Harrisburg, February 4, 1881, a drawing, life size, of a fine fossil *Eurypterus* found by him in the shale immediately beneath the Darlington Cannel Coal bed, Lower Productive Coal measures, with a request to have the specimen studied and described.

Mr. E. B. Harden exhibited two models in plaster, one geologically colored, the other uncolored, of a large part of Blair county, Pa., on a scale of 8000′ : 1″; vertical scale exaggerated 2½ times.

Captain E. Y. McCauley, U. S. N., communicated for publication in the Proceedings an alphabet and syllabary of the Egyptian language, for the use of students, in 82 MS. pages, reducible to 8vo size for the Proceedings.

The Publication Committee reported in favor of a full exchange of all publications, so far as sets could be made, with those of the Musée Guimet at Lyons, which was approved and ordered.

Pending nominations 927 to 933 were read, and the meeting was adjourned.

Stated Meeting, April 15, 1881.

Present, 17 members.

President, Mr. FRALEY, in the Chair.

A photograph of Herr Göppert was received for the album, in a letter of envoy, dated Breslau, March 24, 1881.

Letters of acknowledgment were received from Herr Bernard Studer, dated Berne, March 25 (106 and List), and from the Zool. Soc. Amsterdam (105, 106 and List).

The Physical Section of the Ch. Phy. Soc. Imp. University of St. Petersburg was on motion placed on the list of correspondents to receive the Proceedings.

Donations for the Library were announced from the Russian Academy; Accad. dei Lincei at Rome; Society at Emden; Dr. Otto Wolfenstein of Valencia; Com. Geological Society, Bordeaux; Halifax Library Company; Prof. O. C. Marsh; Mr. Henry Phillips, Jr.; New Jersey Historical Society; Hamilton College, N. Y.; Wyoming Historical & Geological Society; American Journal of Pharmacy, and Am. Jour. Med. Sciences; U. S. Coast Survey; University of Virginia, and Major Jed. Hotchkiss.

A drawing and description of his improved "Centigrad Photometer" was received from D. Coglievina of Vienna.

Prof. P. E. Chase, explained certain relations of the spectrum line F with other lines and data suggesting the probable identity of hydrogen and the luminiferous æther.

Prof. Cope read a paper on the Perissodactyla.

Dr. König made remarks on Dr. P. F. Reinsch's recent plates of the misroscopic lithology of anthracite and other coals.

Mr. Lesley communicated an appendix to Dr. Spencer's paper on the Lake Erie former water-basin, suggesting the probable flow of the upper Ohio from Pittsburgh to Butler, thence, via New Castle, up the present Mahoning Valley and down the Grand Valley of Ohio to Lake Erie.

On scrutiny of the ballot boxes the President declared the following persons duly elected members of the Society.

Prof. Claudio Jannet, of Paris.

Prof. Paul Leroy Beaulieu, of Paris.

M. Emile Malézieux, of Paris.

Prof. E. A. Barber, of West Philadelphia.

Dr. Jas. A. H. Murray, of Mill Hill, London.

Hon. William Butler, Judge of U. S. District Court, Eastern District of Pennsylvania.

Mr. Wm. Woodnutt Griscom, of Philadelphia.

And the meeting was adjourned.

Photodynamic Notes, II. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, April* 15, 1881.)

16. *Weighing the Sun by a Soap Bubble.*

In the well-known experiment of inflating a soap bubble with a mixture of oxygen and hydrogen, and exploding it by a candle, there is an opportunity for studying various radiodynamic relations. The equilibrium which usually exists between the gravitation of the particles towards the sun and towards the earth, is suddenly and violently disturbed. During the restoration of equilibrium, there are simultaneous tendencies to the production of orbital velocities, about the earth and about the sun.

The height of virtual focal projection which represents elliptic orbital velocity is $\frac{r}{2}(1+e)$; the height at Earth's equatorial surface, which is in unison with orbital projection, being $\frac{3962.8}{2} \times 1.01677 = 2014.16$ miles. Dividing this height by the French thermal unit $\left(C = \frac{1389.6}{5280} \text{ mile-pounds}\right)$ and multiplying by 9, because 9 pounds of gas are lifted by 1 pound of combustible, we get 68878.2 calorics as the thermal equivalent of the explosion. Naumann* gives the following experimental values :

Thomsen	68376
Favre and Silbermann	68924
Dulong	69486
Hess	69584
Grassi	69332
Andrews	67616
Mean	68886

* Handbuch der Chemie, p. 290.

The explosive force proceeds radially in all directions from the centre, so that the particles are subjected to cones of force, introducing oscillations which may be represented by a conical pendulum of $\frac{1}{4}$ the height, or 503.54 miles. In seeking equilibrium, the particles tend towards their own centre of gravity, at $\frac{1}{2}$ of 503.54 = 251.77 m., and also, on account of resistance at the Earth's surface, towards the linear centre of oscillation, at $\frac{2}{3}$ of 503.54 = 335.69 miles.

The action of Earth on the centre of gravity of the mass produces a secondary centre of oscillation, in which the primary centre of oscillation acts as a point of suspension, and the centre of gravity as a pendulum-extremity of wave propagation. This secondary centre of oscillation is at $\frac{5}{9}$ of 503.54 = 279.745 m., which represents the mean *vis viva* of oscillatory projection relatively to Earth; the *vis viva* relatively to Sun being represented by Earth's semi-axis major.

Let r = 3962.8 miles; nr = Earth's semi-axis major; t_0 = 1 year = 31558149 seconds; $t_1 = 2\pi\sqrt{\frac{r}{g}}$ = 5078.6 sec.; m_0 = Sun's mass; m_1 = Earth's mass; λ = 279.745 miles. Then we have

$$\left(\frac{nr}{r}\right)^3 : \left(\frac{t_0}{t_1}\right)^2 :: m_0 : m_1 :: nr : \lambda,$$

$$\therefore m_0 = 331,631\ m_1$$

$$nr = 92,772,200 \text{ miles.}$$

17. *Centres of Density and of Nucleation.*

The rotating photodynamic action which is represented by the equations, $\frac{gt}{2}$ = *velocity of light*, $\frac{gt^2}{4}$ = *modulus*, is shown in its greatest simplicity at the nucleal centres of cosmical systems. In all other places it is complicated with orbital motions, which increase the difficulty of determining the sum of the photodynamic actions which are balanced by an equal sum of gravitating reactions. Doubtless methods will be found hereafter for making the proper allowances in all the most important cases; but at present we can take only a few steps towards the goal. The first step, naturally, is from Sun, the centre of nucleation, to Earth, the centre of density. Here we are helped, as in the first instance, by the study of maxima. The limit between association and dissociation at the nucleal centre is the velocity of light, or the greatest known velocity of wave propagation; the centre of density is revolving about the nucleal centre, and its "nascent" limit shows the greatest possible tendency to circular-orbital velocity in the system.

Earth's nascent velocity, if its orbit were strictly circular, would be $\frac{gt}{2} = \frac{86164}{2} \times \frac{32.088}{5280}$ = 261.82 miles. This needs to be multiplied by $(1 + e)^2 = (1.01677)^2$, in order to allow for orbital "subsidence" from aphelion to mean position. We thus get 270.68 miles, for the value of $\sqrt{gr}$ at Sun's equatorial surface. If we knew the precise quotient of Earth's

semi-axis major by Sun's semi-diameter, we could easily compute Sun's mass and distance. Different observers give measurements of Sun's diameter, which vary through a range of about a fourth of one per cent.

In expanding or condensing nebulæ, I have shown that Laplace's limiting or atmospheric radius varies as the $\frac{4}{3}$ power of the nucleal radius. Our first step towards transforming Earth's orbital into nucleal efficient velocity, is to multiply $\frac{gt}{2} \times (1 + e)^2$ by $(1 + e)^{\frac{4}{3}}$. We must also multiply by π, because the time of acquiring the efficient velocity is π times as great as the time of acquiring orbital velocity, and by n*, because Sun's equatorial velocity of rotation is n times as great as the corresponding velocity of rotation when expanded to Earth's orbit. We then have:

Earth's $\frac{gt}{2} \times (1 + e)^2 \times (1 + e)^{\frac{4}{3}} \times \pi n =$ *velocity of light* $= 10089.15 \times 270.68 \div n^{\frac{1}{2}}$.

The right-hand member of this double equation is obtained as follows:

If $\rho =$ Earth's semi-axis major, its orbital velocity is $2 \pi \rho \div 31558149$; the velocity of light being $\rho \div 497.827$. But 270.68 is $n^{\frac{1}{2}}$ times Earth's orbital velocity; therefore, the velocity of light is $\left(\frac{31558149}{2 \pi \times 497.827} = 10089.15\right) \times 270.68 \div n^{\frac{1}{2}}$.

Solving the equation, we find: $n = 214.4775$; $v_\lambda = 186,385.7$; $\rho = 497.827 \; v_\lambda = 92,787,850$ miles; $m_0 = \left(\frac{\rho}{3962.8}\right)^3 \div \left(\frac{1 \text{ yr.}}{5073.6 \text{ sec.}}\right)^2 = 331,799 \; m_1$.

This purely photodynamic determination of ρ differs by less than $\frac{1}{50}$ of one per cent. from the partially thermodynamic determination in the foregoing note.

18. *Nucleal and Rupturing Centres of Condensation.*

Our next tentative step is to Venus, the nearest and brightest of Earth's sister planets, and the only one which shares with Earth the peculiarity of sometimes having an orbit, in the course of its secular changes of excentricity, which is entirely circular. This fact, together with Earth's central position in the dense belt, indicates a purely nucleal origin for that belt; the other planets showing more obvious evidences of an origin which was partly atmospheric, and of the influences of "subsidence" which were so happily pointed out by Herschel. The nascent *vis viva* of Venus, $\left(\frac{gt}{2}\right)^2_\beta$, was also a rupturing *vis viva* in the dense belt, as is shown by the following relation between Earth's semi-axis major, ρ_a, and Venus's secular perihelion radius-vector, ρ_β.

$$\left(\frac{gt}{2}\right)^2_a : \left(\frac{gt}{2}\right)^2_\beta : : \rho_a : \rho_\beta \quad \text{..............................(1.)}$$

*n represents the quotient of Earth's semi-axis major by Sun's semi-diameter.

Let us take for m_α the value given by Note 17; for m_β, Hill's estimate, $\frac{1}{427840}$; for t_α, $23^h\ 21^m = 84060$ sec. Then

$$\frac{42030}{427840} \times \frac{1}{r_\beta^2} = \left(\frac{gt}{2}\right)_\beta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.)$$

$$\frac{42032}{331799} \times \frac{1}{r_\alpha^2} = \left(\frac{gt}{2}\right)_\alpha \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.)$$

Introducing Stockwell's value, $\rho_\beta = .672241$, together with (2) and (3), into (1), we have

$$\left(\frac{42032}{331799} \times \frac{1}{r_\alpha^2}\right)^2 \times .672241 = \left(\frac{42030}{427840} \times \frac{1}{r_\beta^2}\right)^2$$

Hence we find:

$$r_\beta = .9606\ r_\alpha.$$

Herschel gives .988; Newcomb and Holden, .967; Newcomb, in Johnson's Cyclopædia, .9602; Searle, .96; Chambers, .948.

19. *Centres of Density and Nebulosity.*

Earth's nascent relation to the maximum value of Sun's $\sqrt{gr}$ introduces, as we have seen, the factor of gravitating subsidence to a spheroidal nucleus, $(1 + e)^2$. Jupiter's relation to the same value, indicates the formation of a secondary nucleus, at the centre of primitive nebulosity; for Sun's superficial $\sqrt{gr}$, 270.68, is accelerated, in Jupiter's nascent velocity, in the ratio which is due to solar condensation to Jupiter's secular perihelion, or rupturing atmospheric locus, which is .9397 of its semi-axis major, the greatest eccentricity being .0603. We have, therefore:

$$\left(\frac{gt}{2}\right)_\gamma = (\sqrt{gr})_0 \div .9397 = 288.076 \text{ miles.}$$

Professor Hall's estimate of t_γ is $9^h\ 55^m\ 26^s.5 = 35726.5$ seconds. This gives $g_\gamma = 288.076 \div \frac{t_\gamma}{2} = .016127$ m. $= 2.654\ g_\alpha$; $r_\gamma^2 = \left(\frac{m}{g}\right)_\gamma = \left(\frac{331799}{1047.879} \div 2.654\right) r_\alpha^2$; $r_\gamma = 10.924\ r_\alpha$.

Herschel gives 10.977; Newcomb, 10.85; Searle, 10.93; Chambers, 10.75.

20. *Central Nebulous Rupture and Subsidence.*

The co-ordinate influence which is shown in the nascent velocities of Earth and Venus (Note 18), has an analogue in Jupiter and Saturn. If we represent Jupiter's atmospheric rupturing locus by ρ_γ, and Saturn's locus of incipient subsidence, or secular aphelion, by ρ_δ, we find:

$$\rho_\delta : \rho_\gamma :: (\sqrt{gr})_0 : \left(\frac{gt}{2}\right)_\delta$$

$$10.343 : 4.8868 :: 270.68 : 127.81.$$

Prof. Hall's estimate of t_δ is $10^h\ 14^m\ 23^s.4 = 3683.4$ seconds. Dividing 127.81 miles by $\frac{t_\delta}{2}$, we get $g_\delta = .0069344$ m. $= 1.141\ g_\alpha$; $r^2_\delta = \left(\frac{331799}{3501.6} \div 1.141\right) r^2_\alpha$; $r_\delta = 9.113\ r_\alpha$.

Herschel gives 9.87; Newcomb, 8.86; Searle, 9.01; Chambers, 9.07.

21. *Nodal Coördination.*

We see, therefore, from Notes 17–20, that the five nodal positions, which are of the greatest photodynamic importance in the solar system, show successive coördinating influences of universal æthereal oscillation; for, if we designate nascent velocity $\left(\frac{gt}{2}\right)$ by V,

V_0, or the sum of the reactionary gravitating impulses at Sun's surface during a half-rotation, is the velocity of light.

V_α, or the sum of the reactionary gravitating impulses at Earth's surface during a half-rotation, is due to the sum of the reactionary impulses at Sun's surface during the time of communicating orbital velocity, $\sqrt{\frac{r}{g}}$; part of the velocity being compensatory of orbital subsidence, and the rest giving axial rotation.

V_β, or the sum of the reactionary gravitating impulses at Venus's surface during a half-rotation, is due to the belt-rupturing impulses of the reactionary impulses at Earth's surface.

V_γ, or the sum of the reactionary gravitating impulses at Jupiter's surface during a half-rotation, is due, in part, to the sum of the reactionary impulses at Sun's surface during the time of communicating orbital velocity, and in part to the acceleration of Sun's atmospheric condensation to the locus of nebular rupture.

V_δ, or the sum of the reactionary gravitating impulses at Saturn's surface during a half-rotation, is the incipient velocity which, when accelerated by solar atmospheric subsidence to the rupturing locus of its belt, became equivalent to the sum of the reactionary impulses at Sun's surface during the time of communicating orbital velocity.

The joint relations of Earth's eccentricity, Earth's semi-axis major, Sun's semi-diameter, the velocity of light, planetary velocity, nascent velocity of Sun and Earth, and Sun's equatorial velocity of rotation, which are shown in Note 17, are wholly inexplicable upon any hypothesis which fails to recognize the equal actions and reactions of an elastic medium. They are all, however, simple and natural results of photodynamic influence. Sun's nascent velocity is the velocity of light, V_0; the limit of circular-orbital velocity ($V_1 = (\sqrt{gr})_0 = 270.68$ miles), is equivalent to $V_0 \div (1 + e)^{\frac{4}{3}} \pi n$; Earth's nascent velocity $\left(\frac{gt}{2}\right)_a = 261.82$ miles, is equivalent to $V_1 \div (1 + e)^2$; Sun's equatorial velocity of rotation ($V_2 = 1.233$ miles), is equivalent to $\frac{(1 + e)^{\frac{4}{3}}}{n} \times \left(\frac{gt}{2}\right)_a$.

22. *Boundaries of the Dense Belt.*

The uncertainty of Mercury's mass makes any attempt to determine its nascent velocity merely provisional. It seems probable, however, that it bears the same proportion to Earth's nascent velocity as Mercury's radius

of incipient subsidence, or secular perihelion (.477), bears to Earth's semi-axis major. If such is the case, it furnishes another instance, like the inner moon of Mars, of the establishment of a nucleolus, by subsidence within a condensing nucleus. If we take Encke's mass, $\frac{1}{4865751}$, and Herschel's time, $t = 24^h\ 5^m$, the proportion

$$.477 : 1 :: \left(\frac{gt}{2}\right)_\xi : \left(\frac{gt}{2}\right)_\alpha$$

gives

$$r_\xi = .379\ r_\alpha.$$

Herschel gives .396; Newcomb, .378; Searle, .34; Chambers, .374.

Mars, the outermost of the dense belt of planets, furnishes clear evidence of the dependence of nascent velocity upon photodynamic influence. If we designate the centripetal photodynamic acceleration at Earth's semi-axis major by ϕ_α, and the action at the mean secular aphelion of Mars by ϕ_η, we find

$$\left(\frac{gt}{2}\right)_\alpha : \left(\frac{gt}{2}\right)_\eta :: \phi_\alpha : \phi_\eta :: 1.64416^2 : 1^2$$

Substituting Hall's values for m_η, $\left(\frac{1}{8093500}\right)$, and t_η, $(24^h\ 37^m\ 22^s.7)$, we get

$$r_\eta = .546\ r_\alpha$$

Herschel gives .517; Newcomb, .531; Searle, .52; Chambers, .621.

23. *Fourier's Theorem.*

In the activities of the luminiferous æther we may reasonably look for abundant evidences of the truth of Fourier's theorem: "Every periodic vibratory motion can always, and always in one manner, be regarded as the sum of a certain number of pendulum vibrations."* In Note 5, I gave an estimate of the mass at the centre of condensation, which was based upon this theorem. The same value may also be obtained as follows: If we consider simple lines of force, in homogeneous nebular condensation, we find the centre of gravity coincident with the linear centre, and the centre of oscillation at two-thirds of the distance from a point of suspension, or principal inertia, to a point of oscillation, or inferior inertia. If we consider radial action from or towards a centre, we know that the oscillations of a conical pendulum are synchronous with those of a linear pendulum of four times the length. We know, moreover, that centripetal acceleration varies as the fourth power of the velocity of circular orbital revolution. In the conversion of tendencies to nucleal rotation into tendencies to orbital revolution, the oscillating particles are, therefore, subjected to central influences which may be represented by $(2 \times 3 \times 4)^4 = 331776$, which is the ratio of the mass at the centre of nucleation to the mass at the centre of condensation, as estimated in Note 5. It differs by less than $\frac{1}{25}$ of one per cent. from the value found in Note 16, and by less than $\frac{1}{14}$ of one per cent. from the value found in Note 17.

* Prof. Mayer's statement of the theorem, in Am. Jour. Sci. [3], viii, 85.

[illegible]

[illegible]

[illegible]

[illegible]

respectively. These velocities vary as $\left(\frac{m}{r}\right)^{\frac{1}{2}}$, and if we take the values of r which were found by comparing the axial periods, with the values of m, which were assumed in comparison (Notes 17, 18, 22), we find :

$v_3 : v_1 :: 1 : .4242$	Mercury's semi-axis major .3871
$v_3 : v_2 :: 1 : (.7255)^{\frac{1}{2}}$	Venus's " " .7233
$v_3 : v_4 :: 1 : (1 \div 1.502)^2$	Mars's " " 1.5237

All of these ratios point to influences operating within the orbits of the respective planets. The ratio between Earth and Mercury indicates simultaneous nucleolar condensation within a primitive condensing nucleus; the ratio between Earth and Mars indicates the comparative influence of centripetal photodynamic impulsion, or of orbital gravitation towards the Sun; the ratio between Earth and Venus indicates synchronous harmonic influences of projectile *vis viva* within a rotating nebula.

26. *Satellite Velocites in the Rare Belt.*

Extending the foregoing comparison to the lighter planets, we find :

$v_3 : v_5 :: 1 :$ 5.3838	Jupiter, mean aphelion 5.4274
$v_3 : v_6 :: 1 : (10.3937)^{\frac{1}{2}}$	Saturn, secular " 10.3438
$v_3 : v_7 :: 1 :$ 2.0308	Relative momentum, 29.812
$v_3 : v_8 :: 1 :$ 1.7271	" " 29.567

Jupiter, therefore, falls into the same category as Mercury and Earth, as indicating simultaneous nucleolar condensation within a primitive condensing nucleus; the ratio between Saturn and Earth indicates satellite velocities accordant with their respective velocities of nucleal projection; the Uranian and Neptunian ratios multiplied by their respective mass-ratios, point to a primitive unity of momentum near the outer surface of our system in its early stages of condensation.

If we adopt Newcomb's values for the respective masses of Uranus and Neptune, $\frac{1}{22600}$ and $\frac{1}{19380}$, and take Earth's mass, $\frac{1}{331700}$, for the unit of comparison, we find

	Mass.	Limiting sat. v.	m × v.
Earth,	1	1	1
Uranus,	14.68	2.0308	29.812
Neptune,	17.12	1.7271	29.567

Stockwell gives 29.732 for Neptune's mean perihelion, or rupturing locus, so that Earth's relative momentum : the rupturing momentum :: Earth's mean radius vector : the rupturing radius vector. This seems to be a conclusive evidence of a common rotating influence which embraces the centre of nucleation, the centre of density and the Neptuno-Uranian belt.

27. *Harmonic Relations of the Moon.*

In Note 8, the Moon's mass was shown to be in strict accordance with the requirements of radiodynamic elasticity. The two foregoing notes,

together with the Moon's position relative to the centre of density, make it probable that its distance from the Earth, as well as its mass, may furnish important harmonic indications. We find, accordingly, the following close approximations :

Sun's distance : Moon's distance : : Jupiter's mean locus of subsidence (mean aphelion) : Sun's radius of condensation : : Neptune's mean rupturing *vis viva* : Earth's nebular *vis viva*. This triple proportionality is satisfied by the following values :

$$92{,}996{,}000 : 238{,}847 :: 1168.07 : 3 :: (19.73)^2 : 1$$

This would give 215.22 for the quotient of Earth's semi-axis major by Sun's semi-diameter, which is probably about $\frac{1}{8}$ of one per cent. too large. These slight differences in the approximations to the value of n may be due to solar atmospheric, photospheric and chromospheric modifications.

The approximation of Moon's semi-axis major, measured in units of Earth's semi-diameter (60.28) to the continued product $3 \times 4 \times 5$, is also noteworthy.

28. *The Moons of Mars.*

The linear-pendulum ratio, 3, which was introduced twice in the foregoing note, appears in a vast number of satellite, planetary, stellar and molecular harmonies. The following table, with its influence upon the moons of Mars, is a very striking instance :

$$\begin{array}{rcr}
3^0 & = & 1 \\
3^1 - 3^0 & = & 2 \\
3^2 - 3^1 - 3^0 & = & 5 \\
3^3 - 3^2 - 3^1 - 3^0 & = & 14 \\
3^4 - 3^3 - 3^2 - 3^1 - 3^0 & = & 41
\end{array}$$

The above numbers are harmonic divisors, in the Mavortian system, of a primitive nebular radius which represents proportionate action between the centre of photodynamic planetary inertia (Saturn) and the locus of internal rupture in the dense belt (Venus's mean perihelion). For we have

Saturn, mean rad. vec. : Venus, mean per. : : 9.539 : .698 : : 13.67 : 1

If we take 13.67 semi-diameters of Mars as the nebular radius, $\frac{1}{2}$ the radius would be the locus of primitive rupturing subsidence, a locus which accords very closely with the semi-axis major of Deimus, the outer satellite. This and other accordances are shown in the following table :

Divisors.	Quotients.	Observed	Positions.
1	13.670	13.670	Nebular radius.
2	6.835	6.846	Deimus.
5	2.734	2.730	Phobus.
14	.976	1.000	Semi-diameter.
41	.333	.333	Linear c. of central oscill'n.

The importance of the ratio of harmonic undulation, which has been thus introduced at the outer limit of the dense belt, has a deeper meaning; when we remember that Venus and Earth are the only two planets whose

orbits are ever exactly circular, and therefore the only ones that indicate nebular activities which extend to the very surface of a rotating nucleus.

29. *The Moons of Jupiter.*

We may reasonably look for a greater variety of satellite harmonies in connection with the giant planet which represents the primitive nebular centre of our system, than in connection with any of its subordinate companions. Some of those harmonies have been already indicated in Note 14. It may be well to restate two of them in a different form, together with some others which seem especially significant.

I. If we take axial rotation at the centre of density as the unit of comparison, the synchronous rotation and revolution of the nebular hypothesis has been accelerated 366.2565 fold, by Earth's condensation and other causes. Earth's accelerated rotation, is to the acceleration by fall to a centre of linear oscillation, as Jupiter's synchronous radius is to Callisto's synchronous radius:

$$366.2565 : 9 :: 4332.5848^{\frac{2}{3}} : 16.6891^{\frac{2}{3}}$$

The significance of this rhythmical accordance between the nebular centre and the centre of density is increased by the fact that the nascent velocity at each of those centres is directly traceable to the maximum of planetary velocity ($\sqrt{gr}$ at Sun's surface).

II. The significance is further increased by the fact that Callisto represents the mean centre of gravity of Earth and Jupiter, at Jupiter's rupturing locus. Jupiter's mean perihelion being 4.9782, its distance from Earth's semi-axis major is 3.9782. Jupiter's mass being $\frac{1}{1047.88}$, this relation gives $\frac{1}{331245}$ for Earth's mass, as will be seen in the following proportion, .012585 being Callisto's semi-axis major:

$$3.9782 : .012585 :: \frac{1}{1047.88} : \frac{1}{331245}$$

This estimate of Earth's mass gives 92,736,000 miles for Earth's semi-axis major, and 1,167,100 miles for Callisto's semi-axis major.

III. The harmony of planetary and satellite influences, at the centres of density and of nebulosity, is shown by the proportion,

Jupiter's secular perihelion : Earth's semi-axis major : : Callisto's semi-axis major : Moon's semi-axis major.

$$4.8863 : 1 :: 1,167,100 \text{ miles} : 238,850 \text{ miles}.$$

Herschel's estimate is		237,000 miles.
Lockyer's	"	238,793 "
Chamber's	"	238,830 "
Von Littrow's	"	238,870 "
Newcomb's	"	240,300 "

IV. An elliptic orbital influence, between Jupiter and the dense belt, with a major-axis of 6.181, is indicated by the proportion:

$$6.181 : .012585 :: 186282 : 382.38.$$

The second term of this proportion represents Callisto's semi-axis major; the third term, the velocity of light; the fourth term, the velocity acquired by infinite fall to Sun's surface.

V. The pendulum-factor, 3, appears in the Jovian system, in a primitive radius $= 3^3 \times 1.423 = 38.424$ semi-diameters, 1.423 being the theoretical ratio of the radius of constant volume to the radius of constant pressure.*

The following table shows the influence of harmonic vibrations upon the positions of Jupiter's satellites. The harmonic divisor for Callisto is very nearly $1 + 2a$; the other theoretical divisors have a constant third difference of a.

Theoretical Harmonic Divisors.				Observed Divisors.	Quotients.	
		1	= 1.000	1.000	38.424	Gaseous radius.
	a					
a		$1 + a$				
	$2a$		1.428	1.423	26.998	Callisto.
$2a$		$1 + 3a$				
	$4a$					
$3a$		$1 + 7a$	2.497	2.503	15.350	Ganymede.
	$7a$					
$4a$		$1 + 14a$	3.994	3.993	9.624	Europa.
	$11a$					
$5a$		$1 + 25a$	6.346	6.358	6.048	Io.
	$16a$					
$6a$		$1 + 41a$				
	$22a$					
$7a$		$1 + 63a$				
	$29a$					
$8a$		$1 + 92a$				
	$37a$					
$9a$		$1 + 129a$				
	$46a$					
		$1 + 175a$	38.424	38.424	1.000	Semi-diameter.

30. *The Moons of Saturn.*

The photodynamic centre of planetary inertia presents the following evidences of the influences of æthereal undulation:

I. Titan, Saturn's giant moon, bears witness to the rupturing tendencies at the centres of nebulosity and of planetary inertia, in the proportion:

Saturn's secular perihelion : Jupiter's mean perihelion : : Titan's semi-axis major : Sun's semi-diameter.

$$3.7344 : 4.9783 :: .00817 : .00466.$$

II. The combined influences of orbital revolution at the centre of density, and of Laplace's tendencies to synchronism, are shown in the approximate equivalence of the terrestrial year to 23 orbital revolutions of Titan.

$$366.2565 = 23 \times 15.924;\ \text{Titan's orbital period} = 15.945 \text{ days.}$$

* Proc. Am. Phil. Soc. xiv, 651.

III. Saturn's satellite system presents two sets of harmonic indications, Titan's mass being so great as to establish an independent series of divisors.

	Distance.	Divisors.	Harmonic Divisors.	
Japetus,	64.359	1.000	1.000	
Hyperion,	26.795	2.402	2.397 =	$1 + a$
Rhea, aphelion,	9.747	6.603	6.588	$1 + 4a$
Dione,	6.821	9.436	9.384	$1 + 6a$
Tethys,	5.325	12.087	12.179	$1 + 8a$
Enceladus,	4.300	14.966	14.974	$1 + 10a$
Mimas,	3.351	19.206	19.166	$1 + 13a$
Japetus,	64.359	1.000	1.000	
Titan,	22.084	2.914	2.920 =	$1 + b$
Rhea,	9.526	6.756	6.760	$1 + 3b$
Semi-diameter,	1.000	64.359	64.359	$1 + 33b$

31. *The Moons of Uranus.*

The outer moon of Jupiter, the giant moon of Saturn, and the inner moon of Uranus are the ones which give the most direct testimony to the harmonic influence of planetary oscillations. The primary satellite-harmony is determined by the joint influence of Jupiter, Earth and Sun, in the systems of Earth and Jupiter; Saturn, Venus and Sun, in the system of Mars; Jupiter, Saturn and Sun, in the Saturnian system; Jupiter, Uranus and Sun, in the system of Uranus. The nucleal centre has, therefore, modified all the systems; the centre of nebulosity, all but the systems of Mars and Neptune; the centre of planetary inertia, its own system and that of Mars; the centre of condensation, its own system and that of Jupiter. The influence of each planetary radius appears in its own system; the influence of the radius vector also appears, except in the case of Mars, the outer planet of the dense belt, which shows the interaction of mean planetary inertia in the outer belt and internal rupturing tendencies in the inner belt.

I. The mean rupturing locus of Uranus : Jupiter's mean locus of subsidence :: Sun's semi-diameter : Ariel's semi-axis major.

18.323 : 5.427 :: .00466 : .00138.

II. The outer moon of the Uranian system represents, within less than two per cent., the retarded extremity of a linear pendulum, of which the inner moon represents the centre of oscillation. The harmonic divisor for the second moon, as in the Jovian system, is of the form $1 + 2a$. The subsequent differences are multiples of 5, the range between $1 + 2a$ and $1 + 127a$ being $5^3 a$. The harmonic details are shown in the following table:

	Distance.	Divisors.	Harmonic Divisors.	
Oberon,	22.75	1.000	1.000	
Titania,	17.01	1.337	1.343 =	$1 + 2a$
Umbriel,	10.37	2.194	2.199	$1 + 7a$
Ariel,	7.44	3.058	3.055	$1 + 12a$
Semi-diameter,	1.00	22.750	22.750	$1 + 127a$

32. *Neptune's Moon.*

Is Neptune the outer limit of our planetary system, or may we look for still more distant members of our family of circling orbs? Astronomers find indications of some further source of remote perturbation, and attempts have already been made by Prof. George Forbes and D. P. Todd to furnish a clue to its discovery. More than eight years ago, I communicated to the American Philosophical Society* a planetary series which introduced the ratio of the circumference of a circle to its diameter, which is also the photodynamic ratio, at Sun's surface, between the reactions which represent the velocity of light and the reactions which represent the maximum of planetary velocity at Laplace's limit. The two terms of the series which immediately follow Neptune are 94.38 and 296.52 times Earth's semi-axis major. Forbes, by investigating the perturbations which are indicated by the aphelia of comets, has strikingly corroborated this forecast. The abstract of his memoir read before the Royal Society of Edinburgh says†: "On tabulating the aphelion distances of all the known elliptic orbits of comets, it was found that in no case was there any grouping of aphelion comet distances which did not agree with the distances of planets, except that beyond the distance of Neptune there were two groupings of comet aphelion-distances, one at 100 Earth's radii, the other at 300 Earth's radii, approximately." The perihelion or rupturing positions which are indicated by his investigations are 96.7 and 285.2.

Both of these investigations were entirely independent of my own, and neither of the writers gives any indication of ever having read my paper. There is, therefore, cumulative and conclusive evidence of harmonic influences, beyond the known limits of the planetary system as well as between the interior limits of the system and the Sun. The similarity of those influences, their dependence upon photodynamic action, and their importance as guides to investigation, are shown in the following note (33).

Neptune's satellite-harmony is the only one which involves the consideration of only two of the members of the system, Sun and itself. This fact, as well as the slight secular eccentricity of Neptune's orbit, seems to render it probable that the supra-Neptunian harmonies may indicate asteroidal rather than planetary aggregation. If Neptune represents the primitive belt of subsidence-collision, the corresponding nebular radius was $\frac{3}{2} \times$ its secular aphelion radius-vector, or $45.704 \times$ Earth's semi-axis major. We find, accordingly, that

I. Sun's mass : Neptune's mass : : Nebular radius : Neptune's lunar radius-vector.

$$19380 : 1 : : 45.704 : .00236.$$

II. Sun's semi-diameter : Neptune's lunar radius : : Modulus of light : virtual projection of light-velocity, *very nearly; i. e.*, within 1.3 per cent.

$$.00466 : .00236 : : 1 : .5065.$$

* Proceedings A. P. S., xiii, 140; Feb. 7, 1873.
† The Observatory, No. 38, p. 441.

33. *Infra-Mercurial Photodynamic Nodes.*

In my original anticipation* of harmonic nodes between Mercury and the Sun, I looked for possible unknown planets, planetoid groups, or other seats "of solar and planetary perturbation." The announcement † to the Royal Society, seven weeks afterward, of a sun-spot period which was synchronous with the revolution of the first infra-Mercurial node, furnished conclusive evidence of the predicted perturbations; the observation of supposed planetoid bodies, by Watson and Swift, rendered it probable that some of the perturbation is due to actual planetoid influences; the discussions of planetoid sun-spots, by Kirkwood, Mouchez, Gaillot, and Von Oppolzer, indicated four additional periods ‡ in close accordance with four other harmonic nodes; a sixth node (.139) marks the locus (.140) of orbital time, which is a mean proportion between Earth's day and year; the six inner nodes have important photodynamic relations which merit special consideration.

The *vis viva*, and consequently the modulus of the velocity of any revolving particle, varies inversely as the radius vector. Hence, the photodynamic modulus of aggregating velocity (M_λ) : modulus of reacting mass (M_μ) : : radius of reacting mass (r_μ) : radius of aggregating velocity (r_λ). The quotient of modulus by the radius of rotation is equivalent to $(\pi\, \nu)^2$, ν being the quotient of $\sqrt{gr}$ by the velocity of rotation. The controlling bodies of the system are Sun and Jupiter, and if we take Jupiter's mass as the revolving unit of mass, Sun, the reacting mass, will be represented by 1047.879. If n designates the quotient of Earth's semi-axis major by Sun's radius (r_μ), $M_\lambda = \left(\dfrac{31558149}{497.827 \times 2\, \pi\, n^{\frac{1}{2}}}\right)^2$; $M_\mu = (\pi \times 1047.879)^2$. If $n =$ 214.5, $M_\lambda = (688.878)^2$; $\nu = 688.878 \div \pi = 219.28$: $r_\lambda = M_\mu \div M_\lambda =$ 23.84; the time of revolution at Sun's surface (t_0) $= 31558149$ sec. $\div\, 214.5^{\frac{3}{2}}$ $= 10045.5$ sec.; the time of solar half-rotation, or the time in which gravitating reaction $\left(\dfrac{gt}{2}\right)$ against photodynamic action equals the velocity of light, $(t_\lambda) = \dfrac{\nu}{2}\, t_0 = 12.747$ days; r_λ is the locus which I have designated as Helios,§ or the distance at which a planet would revolve in t_λ. This gives, for the fundamental radius of my harmonic forecasts, 3.5134 × Earth's semi-axis major, which exceeds Jupiter's mean locus of subsidence collision ($\frac{2}{3}$ of 5.2028) by less than 1.3 per cent. The closeness of the independent verifications, by various observers, is shown in the following table:

* Proc. Am. Phil. Soc., xiii, 238; New York Tribune, May 2, 1873.

† Proc. Am. Phil. Soc., xiii, 470.

‡ Ib. xviii, 33, 209.

§ Proc. Am. Phil. Soc., xviii, 35.

Harmonic Prediction.		Calculation from Observation.	
$\frac{1}{1}$	$= 3.513$	Node of subsidence,	3.513
$\frac{1}{5}$	.703	Venus, mean perihelion,	.698
$\frac{1}{9}$	.390	Mercury,	.387
$\frac{1}{13}$	.270	De LaRue, S. and L.,	.267
$\frac{1}{17}$	.207	Kirkwood,	.209
$\frac{1}{19}$	.185	Gaillot, (Watson, II)	.180
$\frac{1}{21}$	.167	Gaillot & M., (Watson, I)	.164
$\frac{1}{25}$	.141	Chase,	.140
$\frac{1}{29}$	.121	Von Oppolzer,	.123

I. The first of the six inner nodes, is $r_\lambda = 22.84$ Sun's semi-diameters, or nearly $= \frac{1}{33}$ Node of subsidence $= .1065$ Earth's semi-axis major. The others are found as follows:

II. $1 \div 366.2565^{\frac{2}{3}}$	$= .0195$	Earth's semi-axis major.		
III. $(9^h\ 55^m\ 26^s.5 \div 1\ \text{year})^{\frac{2}{3}}$	$= .0109$	"	"	"
IV. $2^{\frac{2}{3}} \div 214.5$	$= .0074$	"	"	"
V. $\left(\frac{4}{3}\right)^{\frac{2}{3}} \div 214.5$	$= .0057$	"	"	"
VI. $1 \div 214.5$	$= .0047$	"	"	"

All of these nodes represent synchronous oscillations which are due to mutual actions and reactions among the three important centres of nucleation (Sun), condensation (Earth), and nebulosity (Jupiter). While they are all, unquestionably, radiodynamic, their simple dependence upon the equality between Sun's nascent velocity and the velocity of light obviously refers them to the photodynamic branch of radiodynamics. Can any good reasons be given for regarding them as in any sense thermodynamic or electrodynamic?

The accordance of these six inner nodes of synchronism with the harmonic nodes, is shown in the following table:

	Harmonic nodes.		Synchronous nodes.	
I.	$\frac{1}{33}$	$= .1065$	.1069	Velocity of light.
II.	$\frac{1}{177}$	.0199	.0195	Earth's day.
III.	$\frac{1}{321}$	.0109	.0109	Jupiter's day.
IV.	$\frac{1}{465}$	.0076	.0074	Two revolutions at r_μ.
V.	$\frac{1}{609}$	.0058	.0057	Solar subsidence.
VI.	$\frac{1}{753}$	.0047	.0047	Sun's semi-diameter.

34. *Photodynamic Projection of Hydrogen.*

The principles which are involved in Note 16 and in the first synchronous node of the foregoing note, are further illustrated by the simple relations which the molecular velocity of hydrogen bears to the velocity of light (v_λ), the velocity of equatorial solar rotation (v_r), and Earth's secular eccentricity. The reaction of gravitation against photodynamic action, at the centre of any stellar system, requires that

Modulus of light : Stellar semi-circumference :: $v_\lambda : v_r$.

The projections of hydrogen in solar explosions, together with the many indications that hydrogen represents the first known stage of æthereal condensation, make it probable that Earth's orbital projection $\left(p = \frac{1+e}{1-e}\right)$, and the molecular velocity of hydrogen (v_h) may also be directly dependent upon photodynamic action. Such dependence is shown by the equation

$$p\, v_h = v_r.$$

The secular value of p, according to Stockwell, is $\frac{1.0338}{.9662} = 1.06994$; molecular velocity of hydrogen v_h, at the temperature of maximum water-density, is $\sqrt{\frac{277}{273}} \times 6050 = 6094.14$ ft. $= 1.1542$ miles; hence v_r, or Sun's equatorial velocity of rotation, $1.06994 \times 1.1542 = 1.235$ miles. Multiplying by the number of seconds in 12.747 days (t_λ, see foregoing note) and dividing by π, we get 432,931 miles for Sun's semi-diameter, and $214.5 \times 432,931 = 92,863,700$ miles for Earth's semi-axis major. These relations, also, are photodynamically radiodynamic, but it would be difficult to find in them any evidence of thermodynamic or electrodynamic action.

35. *Æthereal, Gaseous and Planetary Densities.*

I have already given two approximations* to the comparative æthereal ratio of elasticity to density, and one approximation† to the relative densities of æther and hydrogen. The accumulating evidences of universal photodynamic energy, leading to various accordant æthereal, gaseous and cosmical harmonies, are such as to justify another tentative step in the same direction. From chemical analogy the planetary aggregations, at the centres of nebulosity (μ_5) and of density (μ_3), may well be presumed to give indications of the comparative energies of condensed and of uncondensed æther. We may, therefore, hypothetically assume that

$\mu_5 : \mu_3 ::$ Projectile gaseous *vis viva* : Æthereal *vis viva*.

The quotient of Sun's mass (μ_0) by Earth's mass (μ_3), which is indicated by the foregoing note, is 332,618. This gives, for the quotient of Jupiter's mass (μ_5) by μ_3, 317.416, and for the velocity of light, 186,538 miles. Substituting these values in the above proportion, and designating the densities of æther and of hydrogen by δ_a and δ_h, we get

$$\frac{317.416}{1} = \frac{\delta_h}{\delta_a} \times \left(\frac{1.235}{186538}\right)^2$$

$$\delta_h = 7,242,500,000,000\ \delta_a$$

This exceeds the ratio which was deduced from æthereal and gravitating interaction† by a little more than six per cent. But in that approximation the factor of terrestrial projection, $p = 1.06994$, was omitted. If we introduce this factor and increase our estimate of Earth's density about $\frac{1}{5}$ of

* Proc. Am. Phil. Soc., ix, 440; xii, 407.

† Ib., xix, 209.

one per cent., the accordance between the two independent approximations will be exact. If the æthereal density towards the centre of density varies inversely as the square of the distance from Sun, the ratio at Earth's orbital distance should be 333,230,000,000,000,000, representing about two and a half times the æthereal density which Sir William Thomson gives as his lowest estimate.

36. *The Experimentum Crucis.*

At the meeting of the American Philosophical Society in which Dr. Henry Draper announced his discovery of oxygen in the Sun, he proposed that I should test my theory of harmonic æthereal action by an examination of the solar spectrum. I accordingly sent a note to the Society, on the 23d of August, 1877,* in which I showed that the wave-lengths of five of the Fraunhofer lines were in harmonic progression, and that four of them were also figurately harmonic, viz:

Lines.	Wave-lengths.	Divisors.	Harmonic Quotients.
A	761.20	1.0000	761.20
B	687.49	$1.1071 = 1 + 7 \times .0153$	687.56
D_1	589.74	$1.2907 = 1 + 19 \times .0153$	589.76
F	486.52	$1.5661 = 1 + 37 \times .0153$	486.05
H_1	393.59	$1.9333 = 1 + 61 \times .0153$	393.73

The cosmical importance of these harmonies is shown by their relation to the projectile energies of Sun (μ_0) and Jupiter (μ_5), as measured by the product of their respective masses by their perihelion vector-radii. For $\frac{\mu_5 \rho_5 - \mu_0 \rho_0}{\mu_0 \rho_0} = .0153.$

I showed, moreover, that the combined photodynamic influence of the centres of nucleation and of nebulosity, μ_0 and μ_5, is traceable in the remaining Fraunhofer and other subordinate lines, viz:

Lines.	Wave-lengths.	Divisors.	Harmonic Quotients.
C	656.67	$1.1530 = 1 + 10 \times .0153$	660.19
	634.05	$1.1989 = 1 + 13 \times .0153$	634.92
	550.70	$1.3825 = 1 + 25 \times .0153$	550.60
E	527.38	$1.4437 = 1 + 29 \times .0153$	527.26
b	517.70	$1.4743 = 1 + 31 \times .0153$	516.31
	458.66	$1.6579 = 1 + 43 \times .0153$	459.13
G	431.03	$1.7650 = 1 + 50 \times .0153$	431.27

The influence of the pendulum-factor is shown in the tendency to differences among the harmonic divisors, which are multiples of $3 \times .0153$ or sub-multiples of $2^2 \times 3 \times .0153$.

37. *Supra-Telluric Æthereal and Cosmical Nodes.*

The crucial demonstration of the law of harmonic oscillation, in the æthereal medium as well as in the bodies which are whirling in its eddies,

* Proc. xvii, 109–12.

gave conclusive evidence of the importance, in all physical investigations, of studying elastic reaction as well as centripetal or centrifugal action. An important fact, in connection with such comparative study, is the variation of elastic density in inverse geometrical ratio, when distance varies in arithmetical ratio. We may, therefore, look for exponential harmonic relations between planetary positions, of a character analogous to the simple harmonic relations between wave lengths. Let k_α represent the kinetic projectile ratio of Neptune, Sun's semi-diameter being the unit; k_β, the mean projectile ratio of the nebular centre of planetary inertia; k_γ, the projectile ratio of the centre of spherical gyration of the centre of condensation; λ_α, λ_β, etc., the corresponding wave-lengths; t_χ, the ratio of orbital time; t_λ, the ratio of photodynamic time; v_λ, orbital velocity at the rupturing locus of mean planetary inertia; v_χ, orbital velocity at the subsidence locus of mean planetary inertia; n, the quotient of Earth's semi-axis major by Sun's semi-diameter. Then we have:

$$\log.\ k_\alpha : \log.\ k_\beta :: \lambda_\alpha : \lambda_\beta \quad \ldots\ldots (1)$$
$$\log.\ k_\alpha : \log.\ k_\gamma :: \lambda_\alpha : \lambda_\gamma \quad \ldots\ldots (2)$$
$$\lambda_\beta : \lambda_\gamma :: 3^2 : 4^4 \quad \ldots\ldots (3)$$
$$t_\chi : t_\lambda :: v_\lambda : v_\chi \quad \ldots\ldots (4)$$

These four proportions furnish data for estimating the four photodynamic values which are least known, by substituting the six which are best known. In equation (1), the estimates of k_α range between 30.034 n (Stockwell) and 30.070 n (Newcomb), the estimates of n varying from 214.3 to 214.9. As the uncertainty of n is the greater, I adopt it as one of the four unknown quantities, and use Leverrier's intermediate coefficient, 30.067. For λ_α I take the wave-length of the Fraunhofer line A, 7612 ten millionths of a millimeter. In equation (2), in the æthereal sphere of which the centre of condensation is the nucleus, the mean projection of spherical gyration is represented by .4 n, and the radius of solar reaction (k_γ) by .6 n. In equation (3), the numbers 3 and 4 are linear representatives of the exponential radii of synchronous nucleal and atmospheric nebular variation; 3^2 is the pendulum ratio of varying central force; 4^4 is the ratio of variation in the centripetal energy of nodal collisions in paraboloidal aggregation. In equation (4), $t_\chi = (30.037\ n)^{\frac{3}{2}}$; $t_\lambda =$ the solar modulus of light divided by Sun's semi-diameter $= \left(\frac{31558149}{2\ \pi\ n^{\frac{1}{2}} \times 497.827}\right)^2 = 101790260 \div n$; $v_\lambda : v_\chi = \left(\frac{1+e}{1-e}\right)^{\frac{1}{2}}$, e being the maximum secular eccentricity of the planetary aggregation (Saturn) at the nebular centre of planetary inertia. Making these substitutions, we get,

$$\log.\ 30.037\ n : \log.\ k_\beta :: 7612 : \lambda_\beta \quad \ldots\ldots (1)_1$$
$$\log.\ 30.037\ n : \log.\ .6\ n :: 7612 : \lambda_\gamma \quad \ldots\ldots (2)_1$$
$$(30.037\ n)^{\frac{3}{2}} : 101790260 \div n :: (1+e)^{\frac{1}{2}} : (1-e)^{\frac{1}{2}} \ldots\ldots (4)_1$$

Solving the proportions, we find the following accordances :

Theoretical.		Observed.		Ratio of Difference.
n	214.45	214.45	Brit. Naut. Almanac.	0 of one per cent.
k_β	1.1862	1.1842	Stockwell,	$\frac{1}{4}$ " "
λ_β	148.20	148.18	Lockyer,	$\frac{1}{71}$ " "
λ_γ	4215.55	4215.00	Lockyer,	$\frac{1}{71}$ " "

$$(1+e)^{\frac{1}{2}} : (1-e)^{\frac{1}{2}} :: v_\lambda : v_x :: (1.0852)^{\frac{1}{2}} : (.9148)^{\frac{1}{2}} :: (1.1862)^{\frac{1}{2}} : 1 :: (k_\beta)^{\frac{1}{2}} : 1$$

$$k_a = 6441.4$$
$$k_\gamma = 128.67$$
$$\lambda_0 = 16.467$$

The same principles are further illustrated in the following comparative table :

Exponents and Divisors.		Harmonic Roots.	Observed.		Harmonic Quotients.	Observed.
1.0000		6441.4	6441.4	Neptune,	7612	7612 A.
1.05355 =	1 + 3½ × .0153	4125.1	4113.9	Uranus,	7225	7196 a.
1.1071	1 + 7 × .0153	2757.7	2742.6	" c. o.,	6876	6875 B.
1.1530	1 + 10 × .0153	2011.8	2045.6	Saturn,	6602	6567 C.
1.1989	1 + 13 × .0153	1508.5	1510.7	Geom. mean,	6349	6340
1.2448	1 + 16 × .0153	1148.0	1115.7	Jupiter,	6257	6236
1.2907	1 + 19 × .0153	893.6	892.6	$\frac{4}{5}$ "	5898	5897 D.
1.3366	1 + 22 × .0153	707.6	707.6	(167) (168)	5695	5687
1.3825	1 + 25 × .0153	569.1	569.2	(43)	5506	5507
1.4284	1 + 28 × .0153	464.1	457.8	(140)	5329	5274 E.
1.4743	1 + 31 × .0153	383.4	383.3	Mars,	5163	5177 b.
1.5202	1 + 34 × .0153	320.3	326.8	Mars,	5007	5011
1.5661	1 + 37 × .0153	270.5	270.3	Mars,	4860	4865 F.

The "exponents and divisors" are terms of an arithmetical progression, as was shown in the foregoing note, the common difference (.0153 ; Note 36) representing a differential action of Sun and Jupiter, the two controlling masses of the system. Therefore, all the roots which are obtained from 6441.4 by using the series as exponential denominators, are harmonic roots, and all the quotients which are obtained from 7612, by using the series as divisors, are harmonic quotients. The "observed" roots represent the mean planetary distances, if $n = 214.45$; the "observed" wave-lengths are given by Gibbs, in the American Journal of Science,* except a, which is interpolated from Angstrom's table. It is, therefore, evident that the external planetary positions and the most prominent spectral lines are both influenced by the same harmonic oscillations in the æther, modified by the law of density in the planetary nodes, and by the law of simple distance in the excursions of wave-lengths.

Harmonic influence is also shown in the roots which correspond to Uranus's linear centre of oscillation, the geometrical mean between the

* [2] xliii, 4.

centres of nebulosity and of nebular planetary inertia, $\frac{1}{2}$ of Jupiter, the mean distance of asteroids 167 and 168, asteroid 85 and asteroid 149. The four roots between 898.6 and 464.1 are all asteroidal, the centre of asteroidal density being represented by 569.1. Newcomb gives the mean distances of 172 asteroids, of which 104 are at mean distances ranging between 506 and 594. The curve of frequency has a maximum at 566; the mean distance of the four chief asteroids in point of magnitude, Ceres, Juno, Pallas and Vesta, is 567; the mean distance of the five which include the maximum and are limited by equal ordinates of frequency, is 569.1. The mean distance of Mars is an arithmetical mean between 383.3 and 270.8, which correspond very nearly with the secular apsides.

38. *Nodes in the Dense Belt.*

In my harmonic anticipation of intra-Mercurial planets,* I showed that the controlling influence of Jupiter is modified by the nodal influences at the centre of the dense belt. This modification is also shown, and perhaps more strikingly, in the relations between the æthereal and cosmical nodes within the belt. If we begin with Mars, at the outer limit of the dense belt, and take successive increments of $\frac{1}{2}{}^{5} \times .0158$, we find the following accordances:

Exponents and Divisors.	Harmonic Roots.	Observed.		Harmonic Quotients.	Observed.
$1.5202 = 1 + \frac{9}{2}{}^{8} \times .0158$	320.8	326.8	Mars,	5007	5011
$1.6850 \quad 1 + \frac{4}{2}{}^{3} \times .0158$	218.6	214.4	Earth,	4656	4671
$1.7497 \quad 1 + \frac{9}{2}{}^{8} \times .0158$	150.3	149.7	Venus, m. p.,	4350	4810 G.
$1.8644 \quad 1 + \frac{11}{2}{}^{3} \times .0158$	110.4	110.7	" l. c. o.,	4088	3972 H.
$1.9792 \quad 1 + \frac{13}{2}{}^{6} \times .0158$	84.0	88.0	Mercury,	3846	
$2.0939 \quad 1 + \frac{14}{2}{}^{3} \times .0158$	65.9	65.9	" p.,	3635	
$2.2087 \quad 1 + \frac{15}{2}{}^{8} \times .0158$	53.0	55.8	" l. c. o.,	3446	

The infra-Telluric loci which represent the harmonic roots are Venus's mean perihelion; Venus's linear centre of oscillation of incipient subsidence, or of secular aphelion; Mercury, semi-axis major; Mercury, perihelion; Mercury, linear centre of oscillation. All of the harmonic roots, both supra-asteroidal and infra-asteroidal, correspond *precisely* with planetary loci, and *very nearly* with apsidal or mean positions. All the harmonic quotients represent regions of spectral interference, and correspond very nearly with the mean positions of important spectral lines. The numerous evidences which have been adduced of the influence of planetary disturbances upon Sun spots, together with Lockyer's explanation of the spots by "the approach or retreat of vapor," seem to justify a careful and systematic study of the variations in the position and breadth of spectral lines, such as I recommended in my note of August 22, 1877.† By observations at different hours of the day, it would soon be found whether there is any systematic daily variation; three months would suffice for approxi-

* Proc. Am. Phil. Soc., xiii, 237-9.
† Ib. xvii, 112.

mately estimating the disturbing influence of Mercury ; and in a year all the planetary regions of the spectrum might be studied. The relations of the C line to Saturn and to hydrogen may, perhaps, be found specially interesting.

39. "*Basic Lines.*"

The values of λ_0 and λ_γ (Note 37) serve to connect Lockyer's basic-lines with æthereal and cosmical nodes.

Harmonics.	Basic Lines.
$4^4 \times \lambda_0 = 4215.6$	4215
$(4^4 + 7^2) \times \lambda_0 = 5022.4$	5017
$(4^4 + 7^2 + 3^2) \times \lambda_0 = 5170.6$	5170
$(4^4 + 7^2 + 3^2 + 2^2) \times \lambda_0 = 5236.5$	5235
$(4^4 + 8^2) \times \lambda_0 = 5269.4$	5269
$(4^4 + 8^2 + 3^2) \times \lambda_0 = 5417.6$	5416
$4^2 \times 5^2 \times \lambda_0 = 6586.8$	6567

The third and fifth "basic lines" are double. Lockyer gives for the third, b_3, b_4; for the fifth, 5268, 5269. Gibbs gives 5177 for the length of the b line; Angstrom's table gives 5167, 5164, for b_3, b_4. The mean, according to Gibbs' measurements, is 5170. The three hydrogen lines, α, β, γ, correspond nearly with the Fraunhofer lines, C, F, and G, but Angstrom makes the wave-length of the γ line 4340. The three lines may be expressed by $4^2 \times 5^2 \times \lambda_0 = 6586.8$; $(4^4 + 5 \times 2^3) \times \lambda_0 = 4873.7$. $(4^4 + 2^3) \times \lambda_0 = 4346.7$.

40. *Chemical Spectra.*

Soon after my announcement of the accordance between the simple harmonic wave-lengths in the solar spectrum and the exponential harmonic loci in the solar system, I showed * that the law of harmonic vibration also extends to the spectra of chemical elements. The following accordances are especially interesting in relation to the basic lines:

	Normal Differences.	Observed.	
Hg.,	$5428.0 + 2\,\lambda_0 = 5460.9$	5428.0	5461.3
Pb.,	$4390.7 + 6\,\lambda_0 = 5378.7$	4390.7	5377.1
Li.,	$4599.3 + 12\,\lambda_0 = 4796.9$	4599.3	4794.8
Rh., Ir.	$5305.2 + 9\,\lambda_0 = 5453.6$	5305.2	5454.4
Cu.,	$5292.7 + 30\,\lambda_0 = 5786.7$	5293.0	5786.7
As.,	$5335.5 + 51\,\lambda_0 = 6174.7$	5335.5	6175.4
	$5787.3 + 20\,\lambda_0 = 6116.6$	5787.3	6116.7
Zn.,	$4723.2 + 84\,\lambda_0 = 6106.4$	4722.5	6106.4
	$6106.4 + 16\,\lambda_0 = 6369.9$	6106.4	6369.9

The tendency to composite and pendulum multiples of the fundamental line is also shown here; 2, 2×3, $2^2 \times 3$, 3^2, $2 \times 3 \times 5$, $3 \times (2^4 + 1)$, $2^2 \times 5$, $2^2 \times 3 \times 7$, 2^4. The Arsenic line, 5335.5, is $2^2 \times 3^4 \times \lambda_0$; in the two

* Ib. xvii, 297–301.

copper lines which precede the two which I have given, the differences are $\frac{1}{4}$ of 80 λ_0 and $\frac{3}{8}$ of 80 λ_0.

41. *The Corona Line.*

In the communication* which led to my spectroscopic investigations, Dr. Draper anticipated the probability of finding a key to "the 1474 K or corona line." The following accordances may help towards a solution of the mystery. The numbers in the right-hand column are the measurements by Gibbs:

Geometric Wave-lengths.	Observed Wave-lengths.
$4811.9 \times 1.0305^{14} = 6567.8$	C 6566.7
$4811.9 \times 1.0305^{7} = 5321.7$	1474 K 5322.0
$4811.9 \times 1.0305^{4} = 4862.8$	F 4865.2
$4811.9 \times 1.0805^{0} = 4811.9$	G 4810.8

I have shown† that the harmonic densities of C and G are photodynamically represented by the loci of Saturn and Venus. The corona line is a mean proportional between C and G. The exponential ratio of $\frac{F}{G}$ to $\frac{C}{F}$ is the same as the ratio of the mean moment of inertia of spherical rotation to the moment of superficial equatorial rotation. The ratio of $\frac{1474\ K}{F}$ to $\frac{F}{G}$ is the same as the ratio of variation in an expanding or contracting nucleal radius to the atmospheric radius.

42. *The Hydrogen Lines.*

Lockyer gives four hydrogen lines, C, F, γ, h. The corresponding geometric wave-lengths give the equations, $Fh^2 = \gamma^3$; $F^{11} = C^4h^7$.

Geometric Wave-lengths.	Angstrom's Wave-lengths.
$4099.5 \times 1.01435^{33} = 6560.2$	C 6561.8
$4099.5 \times 1.01485^{12} = 4863.9$	F 4860.6
$4099.5 \times 1.01435^{4} = 4339.9$	γ 4340.
$4099.5 \times 1.01485^{0} = 4099.5$	h 4101.2

The most prominent line in the hydrogen spectrum, and the only one in some cases, is F, which, as I have shown, is geometrically connected with the corona line and with important cosmical nodes.

43. *Three Orders of Spectra.*

The two foregoing notes introduce a new order of spectra which seems to be of a more elementary character than either of the two which I have previously considered. The geometrical progression of wave-lengths suggests a repetition of impulse, while the absence of some of the terms of the progression indicates a want of complete homogeneity.

The second order is that of the basic lines, which consists of a combina-

* Proc. Am. Phil. Soc., xvii, 77.

† Ib., xvii, 109-12.

tion of arithmetical repetitions of a fundamental wave-length, which is harmonically related to cosmical nodes.

The third order is the one which first attracted my attention,* consisting of groups of wave-lengths which are in harmonic instead of geometric progression, and indicating, like the first order, a want of complete homogeneity.

These three orders are variously blended in the spectra of so-called chemical elements. The character of the blending may, perhaps, serve as a guide towards the resolution of the spectra into simpler constituents.

44. *Æther, Corona, Hydrogen.*

In a communication to the Society, on the 18th of December, 1863, I showed that there is some elastic influence between Sun and Earth, which enables us to form approximate estimates of Sun's mass and distance. At the close of the communication was the following paragraph.†

"The revolution of the Sun around the great Central Sun must also cause barometric fluctuations that may possibly be measured by delicate instruments and long and patient observations. The Torricellian column may thus become a valuable auxiliary in verifying or rectifying our estimates of the distances and masses of the principal heavenly bodies."

In various subsequent communications I have shown that electricity, magnetism, solar gravitation and rotation, planetary and stellar positions, spectral lines, chemical affinity, thermal energy, and other physical manifestations,‡ furnish marked indications of an all-pervading elastic medium, vibrating with the velocity of light, and subject to the same laws of harmonic nodal action as have been found to influence the air and other elastic bodies.

The observations upon the solar eclipse of 1869, by Morton, Winlock Young, Pickering, Harkness and others, disclosed an important line in the solar spectrum, which corresponds very nearly to 1474 of Kirchhoff's scale, and is now styled 1474 K, or "the corona line." Father Secchi attributed the line to hydrogen ; Dr. Gould thought it identical with the auroral line, and therefore due to some substance which, as stated by Lockyer,§ "may possibly be present in the higher regions of our own atmosphere."

Lockyer ‖ considers the observations as indicating "an enormous envelope of hydrogen, probably in the average twelve minutes high," as well as "the existence of some unknown element extending further from the photosphere even than hydrogen." In the eclipse of 1870, "at the same time that this line was observed to extend to a distance of 20′ from the Sun, the lines of hydrogen were observed eight minutes above the Sun." Here are, therefore, probable evidences of two successive stages of æthereal condensation. It has "been shown by Salet, Schuster and others, that" all the hy-

* Ib., xvii, 109–12, 297–301.

†Ante, ix., 288; Phil. Mag. [4], xxviii, 59.

‡Ante, ix, xiv; xvi, sqq.; P. Mag. [4], vols. 30, 32, 34, 35, 50; [5], 1-6, 10, 11.

§Solar Physics, p. 269.

‖ Ib. p. 413.

drogen lines but F are "due to impurities," * so that the hydrogen spectrum is harmonically connected with the corona line.

It may be well to recapitulate, in this connection, some of the simple equations which serve to connect the energies of solar and terrestrial rotation, planetary revolution, atmospheric limitation, molecular oscillation, cosmical aggregation, and ætheral action :

1.	$M : \pi r : : v_\lambda : v_r$	Note 34.
2.	$v_r = p\, v_h$	Note 34.
3.	$v_\lambda = \left(\frac{gt}{2}\right)_0$	Notes 33, 37.
4.	$v_0 = p\left(\frac{gt}{2}\right)_s$	Note 17.

See, also, Proc. Am. Phil. Soc., xii, 392–4 ; xix, 21–5, and Note 16.

45. *Cosmical Significance of the Corona Line.*

Earth being the centre of density in the solar system, its nascent locus should have a time of revolution π times as great as its own, with a semi-axis major of $\pi^{\frac{2}{3}} \times 214.45 = 460.002$ solar semi-diameters. The corresponding wave-length (Note 37,) is 5321.35, as is shown by the following proportion :

log. 6441.4 : log. 460.002 : : 7612 : 5321.35.

This differs by less than $\frac{1}{133}$ of one per cent. from the geometric wave-length (Note 41), and by less than $\frac{1}{80}$ of one per cent. from Gibbs's measurement of the corona line.

The Systematic Arrangement of the Order Perissodactyla. By E. D. Cope.

(*Read before the American Philosophical Society, April* 15, 1881.)

PERISSODACTYLA.

This, the second great order of the ungulate Mammalia, naturally occupies a position between the *Amblypoda* and the *Artiodactyla.* Its lower forms are more specialized in the structure of the feet than the *Amblypoda,* while its highest types do not reach the perfection of structure seen in the *Artiodactyla.* This is particularly indicated by the form of the astragalus, which has but one, the tibial trochlea, and never displays the distal one characteristic of the cloven-footed families. The *Perissodactyla* occupy, as regards their dentition, a position parallel with the *Artiodactyla.* They are always superior in dental complication to the *Proboscidia* and the suilline *Artiodactyla,* but only one series, that of the horses, reaches the com-

* Ib. p. 530, foot-note.

plexity of molars general in the *Ruminantia*. The dentition of the mass of the *Perissodactyla* might be described as intermediate between that of the *Proboscidia* and the lowest selenodont *Artiodactyla*.

The families of this order form a closely connected series, and the division of them into three divisions, the "Pachydermata," "Solipeda" and *Perissodactyla*, has no warrant in nature. Especially unnatural is the conjunction of the genera included under the first name, with the *Proboscidia* and certain suilline *Artiodactyla*, in a single order, as was proposed by Cuvier. The modifications of dentition from the simple type seen in *Menodus*, to the most complex, as in *Equus*, are close and consecutive. So, also, the gradual diminution in the number of digits from 5–4 to 1-1 can be traced through all the intervening stages.

The following definitions of families are applicable in the present stage of knowledge. Those of all but three were published in the Bulletin of the U. S. Geological Survey of the Territories, 1879, p. 228. A modification in the diagnoses of the families *Chalicotheriidæ* and *Palæotheriidæ* is now introduced:

I. Anterior exterior crescent of superior molars shortened, not distinguished from the posterior by external ridge; inferior molars with cross-crests; premolars different from molars.

1. Toes 4–3 .... *Lophiodontidæ*.
2. Toes 3–3 .... *Triplopodidæ*.

II. Exterior crescents of superior molars as in I; inferior molars with cross-crests; superior molars and premolars alike, with cross-crests.

3. Mastoid bone forming part of the external wall of the skull .... *Hyracodontidæ*.
4. Mastoid bone excluded from the walls of the skull by the contact of the occipital and squamosal .... *Rhinoceridæ*.

III. Exterior crescentoid crests of superior molars subequal, distinct; inferior molars with cross-crests.

5. Superior molars and premolars alike and with cross-crests; toes 4–3... *Tapiridæ*.

IV. The external crescentoid crests of the superior molars subequal, separated by an external ridge; inferior molars with crescents.

A. Superior premolars different from molars; with only one internal cusp.

6. Toes 4-3; a vertebrarterial canal .... *Chalicotheriidæ*.
7. Toes 3–3; no vertebrarterial canal .... *Macraucheniidæ*.

AA. Premolars like molars, with two internal lobes above.

8. Toes with digits, 4–3 .... *Menodontidæ*.
9. Toes with digits, 3–3 .... *Palæotheriidæ*
10. Toes with digits, 1–1 .... *Equidæ*.

The genera included in these families are the following. The table shows their geological distribution :

	Eocene. Lower	Eocene. Upper	Miocene. Lower	Miocene. Middle	Miocene. Upper	Pliocene.	Recent.
Lophiodontidæ.							
Hyracotherium Ow.	12						
Pliolophus Ow.	4	2					
? Lophiotherium Gerv.		1					
Pachynolophus Pom.	3	3					
Helaletes Marsh		3					
Lophiodon Cuv.	2	11					
Hyrachyus Leidy		9					
Colonoceras Marsh		1					
Triplopidæ.							
Triplopus Cope		2					
Hyracodontidæ.							
Hyracodon Leidy			2				
Rhinocerontidæ.							
Aceratherium Kaup			3				
Cœnopus Cope			2				
Diceratherium Marsh				3			
Zalabis Cope							
Aphelops Cope					4		
Ceratorhinus Gray				1	2		2
Rhinocerus Linn.					4		2
Peraceras Cope					2		
Atelodus Pom.					2	1	2
Cœlodonta Bronn						3	
Tapiridæ.							
Listriodon Gerv.				? 3			
Tapirus Linn.						6	5
Elasmognathus Gill							1
Chalicotheriidæ.							
Rhagatherium Pict.	1						
Leurocephalus S. S. and O.		1					
Palæosyops Leidy	1	5					
Limnohyus Leidy		3					
Lambdotherium Cope	2	1					
Propalæotherium Gerv.	1	2					
Chalicotherium Kaup.		3					
Nestoritherium Kaup.				?1			
Meniscotherium Cope	1						
Macraucheniidæ.							
Macrauchenia Ow.					2		

	EOCENE.		MIOCENE.			PLIOCENE.	RECENT.
	Lower	Upper	Lower	Middle	Upper		
Menodontidæ.							
Acoëssus Cope	1						
Diplacodon Marsh		1					
Menodus Pom			2				
Symborodon Cope			6				
Dæodon Cope				1			
Palæotheriidæ.							
Anchilophus Gerv		2					
Paloplotherium Ow		6					
Palæotherium Cuv		3					
Mesohippus Marsh			2				
Anchitherium Kaup			2	4			
Anchippus Leidy				1	1		
Hippotherium Kaup					8	1	
Protohippus Leidy					5	1	
Equidæ.							
Hippidium Owen					2	3	
Equus Linn						5	7

Total number of well determined species, one hundred and eighty-nine.

From the preceding table it can be readily seen that this order was abundantly represented during the Eocene period, and that the recent species are comparatively few. It may also be observed that certain families predominated during certain periods. Thus the prevalent *Perissodactyla* of the Eocene are *Lophiodontidæ* and *Chalicotheriidæ;* those of the Miocene are *Rhinocerontidæ* and *Palæotheriidæ*. The *Tapiridæ* and *Equidæ* characterize the latest tertiary epochs. A genealogical tree of the order may be constructed as follows :

Equidæ.

Rhinoceridæ. Palæotheriidæ.

Hyracodontidæ. Tapiridæ.

Triplopidæ. Menodontidæ.

Lophiodontidæ. Chalicotheriidæ.

Hyracotheriinæ.

The types of the *Lophiodontidæ* and *Chalicotheriidæ* differ only in the two

points of the separation, or non-separation, of the exterior crescents of the superior molars, as already pointed out. That no great modification of known forms (as *Lambdotherium* in the *Chalicotheriidæ*, and *Hyracotherium* in the *Lophiodontidæ*) would be necessary to obliterate this difference, is quite clear. The parent types of the order, which present the most generalized dentition, *Hyracotherium*, *Rhagatherium*, and *Acoëssus*, were cotemporaries of the Lower Eocene epoch.

LOPHIODONTIDÆ.

This family embraces a larger number of known species than any of the others of the order. With one exception, all the species belong to the Eocene period. They range from the size of a rabbit to that of an ox. They resembled most, among living animals, the tapirs.

The genera are characterized as follows :—

I. External lobes of superior molars well separated and little flattened; lobes of inferior molars scarcely united (*Hyracotheriinæ*).

A. No diastema behind first premolar.

a. Third and fourth inferior premolar like the first true molar.

Last inferior molar with five lobes .... *Lophiotherium*.

AA. A diastema behind the first premolar in both jaws.

a. Last inferior premolar different from first true molar;

Last inferior molar with heel; cross-crests of superior molars interrupted; *Hyracotherium*.

aa. Last inferior premolar like first true molar;

True molars as in *Hyracotherium* .... *Pliolophus*.

II. External lobes of superior molars flat, not well distinguished. (*Lophiodontinæ*.)

"*A*. No diastema in lower jaw.

Last inferior molar with third lobe .... *Helaletes*."

AA. Lower jaw with diastema.

* No diastema behind first premolar.

a. No inferior premolars like the true molars.

Superior molars 7.

Last inferior molar with heel .... *Pachynolophus*.

Superior molars 6;

Last inferior molar with heel .... *Lophiodon*.

Last lower molar without heels, no horns .... *Hyrachyus*.

Last lower molar?; "an attachment for a dermal horn on each nasal bone" .... *Colonoceras*.

The geographical range of these genera is as follows :—

North America only......... .... *Helaletes*, *Colonoceras*.

North America and Europe ; *Pachynolophus, Hyrachyus, Hyracotherium, Pliolophus.*

Europe only ; *Lophiodon, Lophiotherium.*

Four of the genera ascribed to North America have come under my observation.

Fig. 1. Part of right maxillary bone of *Pachynolophus singularis* Cope; from the Wasatch beds of New Mexico, from Capt. Wheeler's report iv ii pl. lxvi.

TRIPLOPIDÆ.

Cope, American Naturalist, 1881, April (March 25th), p. 340.

But one genus of this family is known at present, but the number will probably be increased when the structure of the feet of various imperfectly known species is ascertained.

TRIPLOPUS Cope.

American Naturalist, 1880, p. 383 (April 27th).

Dental formula, I. ? ; C. $\frac{1}{1}$; P–m. ; $\frac{4}{4}$; M. $\frac{3}{3}$; a considerable diastema anterior to the first premolar. Molars with only two vertical external ridges, the anterior cingular and the approximated median of the anterior crescent. Transverse crests two, uninterrupted and rather oblique ; a ? third and short crest, on the posterior base of the first true molar. Premolars different from molars, the third and fourth with two transverse crests. Inferior molars with two transverse crests, as in *Lophiodon,* the last without heel.

An ossified inferior wall of the meatus auditorius externus. Posttympanic and paroccipital processes distinct form each other. No postorbital arch. Postparietal and mastoid foramina preserved ; the latter large. Cervical vertebræ rather long ; axis with subcylindric odontoid process. Scapula with small coronoid process. Great tuberosity of humerus long, curved. No trochlear crest on condyles of humerus ; epicondyles rudimental. Ulna and radius distinct throughout their length ; ulnar articulation with carpus, small. Trapezoid bone of carpus with a facet for the trapezium. Unciform with two inferior facets. Metacarpals three principal ones, and one, the fifth, rudimental ; the distal extremities of the second and fifth opposite ; the third a little longer.

The dentition of this genus is nearly that of *Hyrachyus.* The only exception is the possible third transverse crest of the first true molars*. The other portions of the skeleton known, are also much like those of *Hyrachyus,* with the exception of the number of digits of the anterior foot. The entirely rudimental character of the fifth metacarpal, which with its

* This point is further considered in the description of the species.

digit, is so well developed in *Hyrachyus*, places *Triplopus* in another family, and in another line of descent. I think that it must be regarded as one of the forms of the series connecting the tapirs with the rhinoceroses. The fourth digit (the fifth) was retained by the earliest type of rhinoceros in Europe, the genus *Aceratherium*, but in America it appears to have been lost earlier. None of the American rhinoceroses of the Lower Miocene of the genus *Cænopus* Cope present it, and in the present genus we have an ancestral type of the Eocene period, in which the last digit is already lost. The premolars of different structure from the true molars, exclude this genus from the *Rhinocerontidæ*, and with the character of the feet place it between that family and the *Lophiodontidæ*.

As yet, but one species of *Triplopus* is certainly known, but a second is placed in it provisionally.

TRIPLOPUS CUBITALIS Cope.

American Naturalist, 1880, p. 383.

This species is represented by a nearly entire skull with lower jaw; most of the cervical vertebræ; a left anterior limb nearly complete; a part of the left scapula, and a part of the right anterior limb; all belonging to one animal. The specimen was not quite adult, as the last superior molar is just protruding its crown through the maxillary wall, and the last two superior milk premolars still remain in place, much worn and closely pressed by the overlying successional teeth.

The *cranium* is peculiar in its wide orbital region, and short compressed muzzle; the latter is damaged in the specimen so that the form of the nasal bones cannot be determined, except at their proximal portions. The interorbital space is plane in both directions, and rises very gently posteriorly. The sagittal crest is narrow and low, until above the meatus auditorius, where it rises. Above the posttympanic process it bifurcates, and each rounded lateral lobe extends posteriorly to a point above the occipital condyles. Viewed from above the head is wide between the zygomatic fossæ, and at the posterior premaxillary teeth. The top of the muzzle narrows rapidly above the latter, but does not contract below until the first premolar is reached. The zygomatic arch is not convex along its middle, and encloses a narrow fossa. The superciliary border is prominent, and nearly straight, and is bounded by a notch behind. The squamoso-occipital ridge is well marked. The posttympanic process is shorter than the paroccipital, and is separated from it by an open shallow groove, which is probably bottomed by the mastoid bone. The paroccipital process is much narrowed below and is turned a little outwards. There are two closely adjacent tubercles on the anterior border of the orbit, probably on the lachrymal bone.

Foramina. Only a few of these are well preserved; among the lost is the *f. infraorbitale*. There are two postparietal foramina on one side, and one on the other, above the point of origin of the zygomatic process of the squamosal bone; and one in the usual posterior position. The post-squamosal has the same anterior position as the anterior postparietals,

being immediately below them; I cannot discover whether there is a posterior one or not owing to injuries to the specimen. There is apparently a fissure-like one on the parieto-squamosal suture posteriorly. The mastoid is quite large, expanding downwards and outwards; it is not so large as in a tapir, but much exceeds that in *Hyrachyus eximius*. The *meatus auditorius externus* is large, and occupies only the posterior part of the space between the postglenoid and posttympanic processes. It is enclosed anteriorly and below by the border of a wide element which may be tympanic. It encloses the petrous bone below in a bulla; as however the inner portion of the best preserved one is broken away, I cannot speak of its relations to the basiocoipital bone. The *foramen lacerum posterius* is reduced to a jugular and perhaps another connected foramen by the close apposition of the petrous bone to the basioccipital for a considerable distance. The region of the *f. l. medius* is injured. Posterior to the *f. l. posterius* is a foramen opposite the base of the paroccipital process, anterior to the usual position of the *f. condyloideum*.

Mandible. The angle of the lower jaw is produced posteriorly, as in some species of *Hyrachyus:* cfr. figs. Vol. IV, U. S. Geol. Surv. Terrs. The coronoid process is long and is curved backwards to above the posterior border of the condyle. There is no tuberosity behind the condyle. The symphysis is quite contracted and is short. The mental foramen is below the middle of the inferior diastema. The ramus is compressed and at the same time strong.

Dentition. As the deciduous third and fourth premolar teeth, in a worn condition, remained in the maxillary bone, I removed them from one side, thus displaying the crowns of the corresponding permanent teeth. The first premolar may belong to the permanent dentition; the second is the deciduous. The former has two roots. The crown is cutting for a short distance anteriorly, but posteriorly it expands into a heel, much less developed than the internal lobe of the succeeding teeth. The crowns of the third and fourth premolars differ externally, as well as in their crests, from those of the true molars. The median-anterior and cingular vertical ridges are not so prominent as in the latter. The external crest is not divided into two by the notch in its grinding face. The anterior cross-crest, at its inner or distal extremity, is turned shortly backwards and then inwards, giving a "pot-hook" outline to its triturating surface. The fourth deciduous premolar presents a peculiar character already ascribed to the first true molar. This consists of a crest running parallel with the posterior transverse crest and close to it, along its posterior side. It forms the border of the tooth for a short distance, but as its direction is slightly obliquely forwards as well as outwards, the posterior cingulum appears for a very short distance.

The first true molar is subquadrate in outline. The anterior transverse crest commences at the middle anterior ridge, and is first transverse, then directed a little obliquely backwards. The second crest commences at the apex of the posterior external crescent, leaving a wide posterior marginal

fossa. Its internal extremity is broken off. Posterior to, and in contact with it, the posterior cingulum rises in a crest, which occupies the internal half only of the border. Its inner border is imperfect. It appears to me to be probable that the normal posterior crest is turned posteriorly on itself so as to give the "pot hook" shape seen in the anterior crest of the fourth permanent premolar. The corresponding accessory crest in the fourth temporary premolar appears to have been distinct at its internal extremity. The second true molar has a more oblique posterior external crest, and the posterior internal is oblique and simple. It has narrow anterior and posterior basal cingula. There is no tubercle between the inner bases of the transverse crests of this or the last true molar. The latter is characterized by the rudimental character of the posterior external crescent crest, which is shortened like that of *Hyrachyus*. The transverse crests are curved backwards; the posterior is short and simple.

The canines are small, and are directed forwards. The extremity of the muzzle being broken, the relation of the incisors cannot be stated, but there was not probably any precanine diastema. An incisor preserved has the crown transversely expanded, and rather oblique.

The third and fourth inferior premolars are the deciduous ones, and are both three-lobed, but differ in the forms of the anterior lobe. In the third, it is narrow and incurved, as in the corresponding permanent teeth of some *Artiodactyla*. The transverse crests of the true molars are rather oblique, running forwards as well as outwards.

Their external extremities are bent at right angles, and there results a short descending crest running forwards and inwards; the anterior one turns inwards, again forming a transverse anterior ledge. No cingula on internal or external bases of crown; a rudimental posterior one.

Measurements of Cranium.	M.
Length from front of canine tooth to end of occipital condyles	.128
Length from same to postglenoid process	.096
" " " to end of last molar	.069
" " " to first premolar	.015
" " " to line of front of orbit	.044
Width between superciliary borders	.046
" of zygomata at orbits	.064
" of brain-case at glenoid surface	.048
" of occipital condyles	.028
" of basioccipital bone between *ossa petrosa*	.006
Distance between postglenoid and posttympanic processes	.014
Depth of occiput behind	.033
" of mandible from condyle	.040
" of mandibular ramus at third premolar	.014
" at diastema (axial)	.009
Least width of symphysis	.011

Measurements of Cranium.		M.
Diameter crown third permanent premolar	anteroposterior...	.007
	transverse.	.005
Anteroposterior diameter crown first premolar..........		.0045
Diameters crown first true molar	anteroposterior.....	.010
	transverse	.012
Diameters crown second inferior true molar	anteroposterior	.011
	transverse.	.0075
Diameter of root of inferior canine near crown.........		.0035

Vertebræ. The atlas is about as long relatively as that of the horse. Its transverse processes have more anteroposterior than transverse extent. The summit of the neural arch has a median ridge separating two grooves. The inferior surface of the centrum has a nearly median, obtuse hypapophysis. The axial facets are well separated below. The vertebrarterial canal pierces the base of the transverse process behind and below, and notches it deeply anteriorly. Above this notch the usual perforation of the arch is present. The axis is not relatively quite so long as that of the horse: it is a little longer than in *Hyrachyus eximius*, but rather shorter than in *Hyracodon arcidens* (Pl. CII, Fig. 7). The atlantal facets are spread well apart, and the articulating surface of the odontoid does not connect with them. The latter is rather long, is obtuse, and slightly recurved; it has no raised borders. Between the atlantal faces the inferior surface is plane. Posterior to this the middle line bears a prominent keel. The diapophyses are long, narrow and recurved, and each is pierced at the base by the vertebrarterial canal. The posterior articular face is but little concave, and a little oblique, and is a little wider than long.

The succeeding cervicals regularly diminish in length, and become more strongly opisthocœlous, the seventh having quite a ball in front. The sixth has a slender diapophysis directed posteriorly, and quite distinct from the wide and long parapophysis which is directed downwards and outwards. The posterior angle of the latter extends as far back as the centrum. The seventh has only a flat transverse diapophysis. The first dorsal has a very stout diapophysis excavated below for the rib tubercle. The diapophyses of the third and fourth dorsals are not so stout. The capitular fossæ are large. The centra of the anterior dorsals are flattened below; they are concealed in part by the matrix in this specimen. The neural spine of the sixth cervical is narrow, and is directed forwards. That of the seventh is vertical, and narrows rapidly from a base which is rather wide anteroposteriorly. The spines of the dorsals are wider, and are directed gently posteriorly; they are probably long, judging from the size of their bases.

Measurements of Vertebræ.	M.
Length centrum of atlas on side......................	.027
" " " below......................	.010
Width " " " posteriorly	.030

Measurements of Vertebræ.			M.
Width transverse process of atlas			.010
Vertical diameter neural and odontoid canal			.015
Length axis to odontoid process			.038
" odontoid process			.007
Diam. centrum behind	vertical	with hypapophysis	.012
		without "	.009
	transverse		.0115
Length of centrum of fifth cervical			.030
" " seventh			.017
" " second dorsal			.014
Anteroposterior diameter of base of neural spine of second dorsal			.010
Expanse of head and tubercle of first rib			.012

Fore Limb.—The greater part of the blade of the scapula is lost. The neck is stout, and the coracoid is a short aliform process. The humerus is moderately robust, most so proximally. The greater tuberosity is a strongly incurved crest, with truncate summit, which is a little elevated above the plane of the head, from which it rises rather abruptly. The bicipital ridges are not strong nor prominent. The olecranar fossa is deeper than the coronoid fossa, and they communicate by perforation. The inner part of the condyle is the largest, and forms an acute angle with the interior epicondylar surface. The exterior part of the condyle is divided by an oblique angle of the surface separating an external bevelled band of the same, which narrows to extinction on the posterior side. As compared with the humerus of *Hyrachyus eximius*, that of *Triplopus cubitalis* is very similar, differing mainly in two points at the distal extremity. The olecranar fossa is smaller and is less excavated, and its lateral bounding ridges are of unequal elevation ; in *T. cubitalis* they are equal.

The ulna and radius are more than one-fourth longer than those of *H. eximius*. Although they are entirely distinct throughout, the ulna is quite slender anterior to the proximal third. The shaft is much more slender than that of *Hyrachyus eximius*. The olecranon is compressed, deep, and truncate behind. The distal epiphysis is remarkable for its length, being twice as long as that of the radius. The head of the radius is subequally divided by fossæ, the external being the shallower. The inferior or ulnar facet is regularly and gently convex downwards, and is bounded behind by a roughened ridge, which, near the external border turns backwards to the humeral border. The shaft of the radius is robust and flattened. The carpal facet of the radius is contracted, and has three times the superficial area of that of the ulna. The scapholunar dividing ridge is present, but is very low. The scaphoid face is the more excavated, and then rolls backwards, forming a very narrow posterior facet, which is narrower than that found in the species of *Anchitherium*. There is no distinct fossa on its inner or posterior border, as in many ungulates. The trapezium and scaphoid are the only bones of the carpus which are wanting. The latter

is probably wider than long or deep, while both the lunar and cuneiform are longer than wide. The cuneiform has not its external border excavated; its proximal surface is oblique and continuous, the ulnar and pisiform facets being in line. The pisiform is large, and is enlarged distally; its proximal facets are equal. The exposed face of the trapezoides is rather larger than that of the magnum, and is nearly as large as its own face of contact with the latter. The magnum has the usual great anteroposterior extension, with elevated posterior convexity applied to the fossa of the lunar. Its posterior process is long, nearly equal to the rest of the bone, and is depressed and flattened distally. The metacarpal facet is very concave. The unciform's anterior or exposed face is a little longer than wide. Its two proximal facets are about equal. It is about as deep as wide, and extends half its length distad to the magnum. Its posterior process is rather narrow; it is narrow and abruptly decurved. Distally, the facet for the fifth metacarpal is well marked, and has about half the area of that for the fourth metacarpal. The functional metacarpals are of moderate length as compared with the elongation of the ulnoradius. The third is largely in contact proximally with the unciform as well as with the magnum. The condyles are stout, and each is laterally impressed by a fossa. The second and fourth have chiefly lateral presentation, but are not much narrower in the shaft than the median metacarpal. The first phalange of the lateral digit is a little shorter than that of the median, while the seconds are of equal length. The extremity of the second digit reaches the proximal third of the length of the median ungual phalange. The fissure of the ungual phalange reaches the middle of its length. The fifth metatarsal is proximally rather stout; but it soon contracts to a thin rounded extremity, at only one-fifth the length of the fourth.

Measurements of Fore Limb.		M.
Antero-posterior diameter of cotyloid cavity of scapula		.015
Diameter of head of humerus	transverse	.020
	anteroposterior	.019
" with greater tuberosity		.030
Length of humerus on outer side		.110
Diameter humerus at epicondyles	transverse	.021
	anteroposterior externally	.015
Length of ulna		.165
" radius		.141
Depth of olecranon distally		.015
Width of ulna at coronoid		.015
" " carpal facet (greatest)		.007
" radius at head		.016
" " carpal facets		.014
" " widest point distally		.016
Length of carpus at magnum		.015
" " unciform		.018

Measurements of Fore Limb.		M.
Length of lunar		.010
Depth "		.011
Length of magnum		.005
Depth "		.017
Length unciform		.009
Width "		.009
Depth " (total)		.014
" " of inferior facets		.007
Length of third metacarpal		.068
Proximal diameter third metacarpal	anteroposterior	.008
	transverse	.008
Length of fifth metacarpal		.012
" median series of phalanges		.027
" first median phalange		.010
Width of do. proximally		.008
Length of second phalange		.006
Widths of median ungual phalange	proximally	.0070
	medially	.0055
	greatest	.007

The body of this animal was about the size of that of a red fox. The legs were more slender or elevated, and the head of course was shorter and thick.

The unique specimen on which our knowledge of this species rests was cut from a block of calcareous sandstone of the bed of the Washakie basin of the Bridger Epoch, near South Bitter creek, Wyoming Territory. The bones are generally in the relation of the position in which the animal died. The neck is depressed and the left fore leg raised so as to be in contact with it, and the head is raised so as to clear the left wrist.

Triplopus amarorum Cope.

The characters of the fore-foot of this species being unknown, it is not possible to determine its generic position. It has, however, one of the well-marked characteristics of the genus *Triplopus*, in the osseous enclosure of the *meatus auditorius externus*, through the ossification of the external prolongation of the otic bulla, and tympanic cartilage. I cannot therefore refer it to *Hyrachyus*.

It is represented by a skull from which a large part of both maxillary bones and the mandible have been lost, and which is accompanied by parts of the ulna and radius, parts of the ilium, a femur, and tibia, and nearly all of the posterior foot of the right side. The posterior parts of both maxillary bones remain, and they support each, the last superior molar tooth from which the external wall has been broken away. The portions of molars remaining exhibit characters which lead me to suspect that the

species does not belong to *Hyrachyus*. The anterior cross-crest of the molar preserved, is lobate, resembling the same ridge in the species of *Anchitherium*. The posterior cross-crest is uninterrupted. If this species possesses affinity with *Anchitherium*, it will perhaps possess three digits of the manus, in which case it will be referred to the *Triplopidæ*, in harmony with the indication furnished by the ear structure.

The *Triplopus amarorum* is much larger than the *T. cubitalis*, equalling the *Hyracodon nebrascensis*. It differs from the *T. cubitalis* in the stronger temporal ridges, and more elevated sagittal crest; also, in the shorter posttympanic process. The internal lobes of the last superior molar are connected by a basal ledge, not found in the *T. cubitalis*.

The interorbital space is wide and flat, and is most expanded at the postorbital angles.

From this point the face contracts rapidly forwards. From the same angle it contracts abruptly posteriorly to the rather narrow brain-case. The anterior temporal ridges are nearly transverse near the postorbital processes, and then converge more gradually, uniting opposite the posterior inferior border of the zygomatic fossa. The elevated sagittal crest diverges into two lateral supraoccipital crests, which contract as they descend, and continue to the extremities of the posttympanic processes. Although the postorbital angles are prominent, they cannot be called processes. The paroccipital processes are large, and are directed vertically downwards. They are separated by the usual concavity from the occipital condyles. The posttympanics are very short, forming only an angle projecting downwards at the anterior base of the paroccipitals, from which they are only separated by a notch. The inferior side of the tympanic bone is flat near the meatus, but opposite the stylomastoid fossa its posterior border is turned forwards, and is produced into a well marked process. It encloses a groove in front of it, which is continuous with the pterygoid fossa. The petrous bone is not inflated, and its inferior surface is divided into two longitudinal ridges. The inner is the less prominent, and is in close contact with the basioccipital. The postglenoid processes are robust and obtuse. The basioccipital is excavated in front of each of the condyles. The inferior surface is nearly flat, with a slight median keel. The pterygoid fossa is well defined, and is long and narrow. The posterior nareal trough is elongate, the descending pterygoid processes of the sphenoid originating as far back as the apex of the *os petrosum*. This species is especially characterized by the presence of an acute keel-like ridge, which extends horizontally above the foramina sphenoörbitale and opticum, and turns upwards anterior to the latter, terminating a half inch below the inferior base of the postorbital process. All the foramina are below it, but there is a fossa above it, opposite the interspace between the *f. opticum* and *f. sphenoörbitale*.

A supraorbital foramen pierces the frontal bone, a quarter of an inch within the superciliary border. There are five or six postparietal foramina, two of which are nearly on the squamosal suture. There is a postsqua-

mosal foramen, and also a not very small supraglenoid foramen. There is a small foramen anterior to the optic, and in line with the posterior part of the postfrontal angle. The *foramen opticum* is large, and is 10mm. in front of the *f. sphenoörbitale*. The latter is separated by a lamina from the large and vertically oval *f. rotundum*. The latter is joined by the large alisphenoid canal, whose posterior orifice is as large as the foramen ovale. The latter is large, and is well separated from the *f. lacerum anterius*. The *f. f. lacera* are well closed up, the *posterius* being reduced to what is probably the jugular foramen. The *f. condyloideum* is large, and is an anteroposteriorly placed oval. Its anterior extremity is opposite to and well separated from the *f. jugulare*.

The nasal bones are spread out posteriorly, and their posterior extremities are truncate. The coronal suture passes downwards at the narrowest part of the cranium behind the postfrontal angles. The squamosal bone does not reach the frontal. The parietal does not extend so far posteriorly as the lateral occipital crests, except near the squamosal.

The characters of the last superior molars have already been mentioned. The posterior transverse crest is uninterrupted, but the anterior consists of closely united internal and median lobes. The division is marked on the posterior side, and on the edge of the crest; the anterior face is plane. The longitudinal external crest sends a strong protuberance into the head of the valley, which is grooved on its surface. There is a strong anterior basal cingulum which rises to an anterior cusp. On numerous surfaces the enamel is slightly rugose. The inferior canine teeth are in continuous series with the incisors, and are slightly larger than they.

Measurements of Skull.		M.
Length from line connecting anterior borders of orbits to occipital crest		0.182
Length from line connecting posterior borders of orbits to occipital crest		.100
Width between postorbital angles		.100
" " anterior borders of orbits		.076
Elevation of occiput		.065
Width between mastoid ridges		.065
" " *ossa petrosa* at middle		.018
Diameters third superior true molar	anteroposterior	.0200
	transverse	.0205
Diam. second superior true molar (base)	anteroposterior	.0200
	transverse	.0150

The portion of ilium remaining exhibits a rather narrow neck and a concave external face. A fragment of the femur shows a prominent third trochanter, with an obtusely rounded apex. The distal part of the fibula is not coössified with the tibia. Its shaft is exceedingly slender. The angles bounding the trochlear grooves and ridges of the tibia are of sub-equal

lengths. The median ridge is rather wide; the inner malleolus is narrow, has no distal facets and no distinct tendinous grooves externally.

The posterior foot is both relatively and absolutely smaller than that of *Hyrachyus eximius*. The trochlea of the astragalus is narrower and more deeply grooved. The crests are obtuse, and not so narrowed as in *Mesohippus bairdi*, nor are the malleolar facets of the astragalus so sharply defined as in the latter species. The external ligamentous fossa is, however, deep, and is bounded anteriorly by a low trihedral tuberosity not found in the *M. bairdi*. The head of the astragalus is not sessile as in *M. bairdi*, and has rather the proportions of *H. eximius*. The cuboid facet is a bevel of the external side of the distal extremity, as in *H. eximius*, and is not on a produced ledge, as in *M. bairdi*. The internal tuberosity of the head is not as much developed as in either of the species named. The navicular face of the astragalus is horizontally divided by a shallow ligamentous fossa. The calcaneum is much like that of *Hyrachyus eximius*. The cuboid face is less oblique than in that species, in the anteroposterior direction, and is less crescentic in outline than in *M. bairdi*. The sustentaculum is rather more extended transversely than in *H. eximius*, but resembles that species more than the *M. bairdi*, in wanting the deep groove at its base on the inferior side, which cuts it off from the rest of the calcaneum. The remainder of the inferior surface is flat, and not grooved for a tendon as in *H. eximius*.

The remainder of the tarsus includes the usual five bones, the three cuneiforms being present. They are in general a good deal like the corresponding bone of *Hyrachyus eximius*. The navicular differs in having a low transverse ridge on its proximal face, which fits the groove of the astragalus already mentioned. The hook of the cuboid is large. The external (anterior) face of the mesocuneiform has one-third the superficial area of the anterior face of the ectocuneiform. The entocuneiform is rather large, and is flat and subsemicircular. Its position is externo-posterior. The ectocuneiform presents facets to both the second and fourth metatarsals, that with the latter the largest. The distal halves of the metatarsals are lost. At their proximal portions they are of subequal width, as in *Hyrachyus eximius*, but the lateral ones are rather narrower at the middles of the shafts.

Measurements.	M.
Width of distal extremity of tibia	.029
" astragalar face "	.019
Length of inner malleolus	.007
" astragalus on inner side	.030
Depth of trochlea " "	.017
" head " "	.0145
Width of trochlea	.015
" navicular facet	.0195
Length of head from inner crest of trochlea	.005
" calcaneum	.058

Measurements.		M.
Length of free part of calcaneum		.087
Distal depth of the calcaneum		.016
Diameters cuboid face calcaneum	anteroposterior	.0145
	transverse	.0145
Length of navicular		.008
" cuboid		.0145
Transverse proximal width of three metatarsals		.027
Diameters of second metatarsal	anteroposterior	.014
	transverse	.007
Antero-posterior diameter of third metatarsal		.0145
Diameters of fourth metatarsal	anteroposterior	.014
	transverse	.012

This species was obtained in 1873 from the bad lands of South Bitter creek, Wyoming, from the Washakie basin of the Bridger formation. The locality is the same as that which furnished the *Triplopus cubitalis*, the *Achænodon insolens*, etc.

HYRACODONTIDÆ.

This family, which I characterized in 1879, includes, so far as yet known, the single genus *Hyracodon*, which is found in the Oligocene White river formation of North America. According to Marsh, the digits of this genus number three on both anterior and posterior limbs. It has a full series of incisor teeth in both jaws.

RHINOCERIDÆ.

This extensive family has left representatives in all parts of the Northern Hemisphere, and species still exist in the Old World. From the following table the range of variation of its genera can be readily seen :

I. Four anterior digits.

Incisors $\frac{2}{1}$; canine $\frac{0}{1}$; no horn ; posttympanic bone distinct. *Aceratherium.*

II. Three anterior digits.

a. Posttympanic process not coössified with postglenoid.

Incisors $\frac{2}{1}$; canines $\frac{0}{1}$; no dermal horn .... *Cænopus.*

Incisors $\frac{1}{1}$; canines $\frac{0}{1}$; no dermal horn .... *Aphelops.*

Incisors $\frac{0}{1}$; canines $\frac{0}{1}$; no dermal horn .... *Peraceras.*

Incisors $\frac{1}{1}$; canines $\frac{0}{1}$; a tuberosity for a dermal horn on each nasal bone. *Diceratherium.*

Incisors $\frac{1}{1}$; canines $\frac{0}{1}$; a median dermal nasal horn .... *Ceratorhinus.*

Incisors $\frac{2}{2}$; canines $\frac{0}{1}$ .... *Zalabis.*

Incisors $\frac{0}{0}$; canines $\frac{0}{0}$; dermal horn median ; no osseous nasal septum.... *Atelodus.*

aa. Posttympanic process coössified with postglenoid ;

Incisors $\frac{1}{1}$; canine $\frac{0}{1}$; dermal horn median ; nasal septum not ossified.... *Rhinocerus.*

Incisors $\frac{0}{0}$; canine $\frac{0}{0}$; dermal horn median ; nasal septum ossified........ *Cœlodonta*

It can readily be seen that the genera above defined form a graduated series, the steps of which are measured principally by successive modifications of four different parts of the skeleton. These are, first, the reduction of the number of the toes of the anterior foot ; second, the reduction in the number and development of the canine and incisor teeth ; third, the degree of closure of the meatus auditorius externus below ; and, fourth, in the development of the dermal horns of the nose and its supports. While these characters have that tangible and measurable quantity which renders them available for generic diagnosis, there are others which possess a similar significance, and which I have noticed in an article published in the bulletin of the U. S. Geological Survey of the Territories for September 1879.

This series may be represented in genealogical relation, as follows :*

Cœlodonta.

Rhinoceros. *Atelodus.*

\

Ceratorhinus. *Peraceras.*

\

Aphelops.

Zalabis. *Cænopus.* *Diceratherium.*

The early type, which corresponds most nearly with *Cænopus*, and which preceded both it and the *Aceratheria* in time, is the genus *Triplopus* Cope, which has left a species in the Upper Bridger of Wyoming. Here the incisors are probably $\frac{3}{3}$ and the canines $\frac{1}{1}$. This formula is that of the Eocene tapirs, where the normal numbers $\frac{3}{3}$ $\frac{1}{1}$ prevail. *Triplopus* further differs in the primitive condition of the premolars above, which, as in the *Lophiodontidæ*, differ from the molars in their greater simplicity. Thus it is probable that tapiroids, probably *Lophiodontidæ*, gave origin to the *Rhinoceridæ*, as Marsh has suggested. And it is further altogether probable that the general type of dentition presented by the *Rhinoceridæ*, *Lophiodontidæ*, etc., which I have named the palæotheriodont, took its origin from the type which is intermediate between it and the bunodont, via, the symborodont, as I have pointed out in an essay on this subject.

The first appearance of dermal horns was apparently in a pair placed transversely on the nasal bones, in species of Eocene *Lophiodontidæ* of the genus *Colonoceras*. The same character has been observed by Marsh in species of the Lower Miocene, which probably belong to the true *Rhinoceridæ*, and which he has called *Diceratherium*. This genus appears to have terminated the line exhibiting this structure, and the family in North America remained without horn. As we have seen, the types possessing the median horn arose in Europe, in the *Ceratorhinus schleiermacheri* of the Middle Miocene, and still survives.

*See American Naturalist, 1880, p. 611.

It may be observed in conclusion that a successive increase of size in the species of this line has taken place in North America with the advance of geologic time. Thus, their probable ancestors of the genus *Triplopus* were the least of all. The *Cœnopoda* of the White River formation were larger; the oldest *C. mite*, being the smallest. The *Aphelopes* of the Loup River or Upper Miocene formation were all larger, and were nearly equal to the large existing species.

TAPIRIDÆ.

The genera of this family are not numerous as yet. The oldest, *Listriodon*, appears in the Middle Miocene (Gers, France), and *Tapirus* is first found in the Upper Miocene (Epplesheim). The recent species of the family belong to *Tapirus* L., and *Elasmognathus* (Gill). A small species, the *Tapirulus hyracinus* Gerv., is from a bed at Perreal, France, which Pictet has identified with the gypsum of Paris (Oligocene). It is sometimes referred to this family, but is not sufficiently well known to determine its position. In America, *Listriodon*, or a genus which has not yet been distinguished from it, is found in the Miocenes.

The three genera are distinguished as follows:

Three anterior premolars different from fourth premolar and true molars; last inferior molar with heel........ *Listriodon*.

One superior premolar different from true molars; no heel of third inferior molar; nasal septum cartilaginous.... *Tapirus*.

Like *Tapirus*, but nasal septum osseous.................. *Elasmognathus*.

CHALICOTHERIIDÆ.

Gill; Cope, American Naturalist, 1881, p. 340.

This family had numerous representatives during Eocene time, and a few species of *Chalicotherium* extended into Miocene time. The boundaries which separate the family from the *Lophiodontidæ* on the one hand and the *Menodontidæ* on the other, are not always easy to determine. From the former the symmetrically developed external Vs of the superior molars, and the double Vs of the inferior molars distinguish it. Yet in *Rhagatherium* the external Vs are not so well distinguished as in other *Chalicotheriidæ*; and in *Propalæotherium*, the anterior cingular cusp produces a part of the assymmetry found in the *Lophiodontidæ*. The character of the double inner cusps of the superior premolars, which distinguish the *Menodontidæ*, is only applicable to the last premolar in *Diplacodon* of the latter, while a trace of the additional cusp of this tooth is found in the Chalicotheroid *Nestoritherium*.

In using the following table it must be borne in mind that the number of the toes has been determined in a very few of the genera. Should any of them prove to have but three digits on the anterior foot, such genera must be referred to a new family intermediate between this one and the *Palæotheriidæ*.

I. Internal cones of superior molars separate from external lobes.

A. Cusps of inferior molars not completely united;

a. External lobes of superior molars more or less conic.

Inferior premolars III and IV compressed, three lobed; a diastema both behind and before P-m. II.......................... ....*Rhagatherium.*

AA. Cusps of inferior molars united into two Vs.

a. Incisors present.

β. No diastema in front of second inferior premolar.

Second premolar without inner lobe; last molar with one inner cone..... *Leurocephalus.*

Second premolar with inner cone; last superior molar with an inner cone...*Palæosyops.*

Second premolar with inner cone; last superior molar with two inner cones...*Limnohyus.*

ββ. A diastema in front of second inferior premolar.

Two inner cones of last superior molar...................*Lambdotherium.*

aa. Incisors absent from both jaws.

Last superior molar with one internal cone...............*Nestoritherium.*

II. One or both internal cusps of superior molars united with the external lobes by cross-crests.

a. External cusps of superior molars more or less conic;

An anteroexternal cingular cusp........................*Propalæotherium.*

aa. External lobes of superior molars, inflected Vs.

β. No crescentic inner lobes.

No intermediate lobes.......... ....*Chalicotherium.*

ββ. One or more lobes of each molar crescentic.

Intermediate lobes, and one internal cone of superior molars............. *Meniscotherium.*

The following regions have thus far furnished species of the above-mentioned genera:

Europe—*Rhagatherium, Propalæotherium, Chalicotherium.*

N. America—*Leurocephalus, Palæosyops, Limnohyus, Lambdotherium, Meniscotherium.*

Asia—*Nestoritherium.*

Of the American genera, *Leurocephalus* S. S. & O. has been found by the Princeton exploring expedition of 1877 in the Bridger formation, but I have not met with it myself. *Meniscotherium* Cope, is known from a single species found by myself in the Wasatch formation of New Mexico, and described in my report to Capt. G. M. Wheeler (1877).

FIG. 2. Part of right maxillary bone of *Meniscotherium chamense* Cope, from the Wasatch bed of New Mexico. From Report Capt. G. M. Wheeler, IV, II, Pl. LXVI.

MENODONTIDÆ.

The known genera of this family are not numerous. They are defined as follows:

I. Vs of inferior molars probably incomplete; superior molars with intermediate tubercles.

Internal cusps of superior molars well separated................*Acoëssus*.

II. Inferior molars with the crowns thrown into two Vs; superior molars without intermediate tubercles.

a. Last superior premolar only with two inner tubercles.

Incisors present..*Diplacodon*.

aa. All the superior premolars with two interior cusps.

Six inferior incisors, canines very large........................*Dæodon*.

Six inferior incisors; canines very small.......................*Menodus*.

No inferior, and four small superior incisors; canine very small.......... *Symborodon*.

The first appearance of this family was in the Early Eocene in the genus *Acoëssus* Cope, which was a cotemporary of *Hyracotherium*, and which it resembles in some respects. Its typical species was called *Hyracotherium siderolithicum* by Pictet, its describer, but Kowalewsky has already expressed the opinion that the species does not belong to that genus. It is from the Lower Eocene of Mauremont, Switzerland. The remaining genera are, as yet, American, excepting one, which is represented by an Austrian species, not yet well known. *Diplacodon*, in its simpler premolars, approaches the *Chalicotheriidæ*, and is the oldest of the American genera. It is from the Uinta or Upper Eocene. *Menodus* and *Symborodon*, which include some species of gigantic size, belong in the White river or Oligocene, while *Dæodon* has so far only been obtained from the Truckee or Upper Oligocene.

MACRAUCHENIIDÆ.

But one genus of this family is known at the present time. The following are the dental characters of *Macrauchenia*. Formula: I. $\frac{3}{3}$; C. $\frac{1}{1}$; P.m. $\frac{4}{4}$; M. $\frac{3}{3}$, forming an uninterrupted series. The superior molars present two external Vs, and two oblique transverse crests, somewhat as in *Palæotherium*. The spinous foramina pierce the neural arch of the dorsal vertebræ (Gervais). There is no intertrochlear crest of the humerus, but the carpal facets of the radius are well distinguished. The internal malleolus is small, but the fibular malleolus is coössified with the tibia at an early age, and articulates with the calcaneum. The trochlea of the astralagus is well developed. The lateral digits are large, and the distal keels of the metapodials are continued on the anterior face of the condyle.

The position indicated by the above characters is a remarkable one. The uninterrupted dental series and the absence of intertrochlear humeral crest, are primitive features among ungulate *Mammalia*. The radiocarpal articulation is facetted as in higher ungulates, but lacks the inferior condyloid face of those types. The completeness of the metapodial distal keels is a feature of high specialization, only seen in the *Equidæ* of this order. The coössification of the external malleolus is also a character peculiar to the *Equidæ* among the *Perissodactyla*. There are two other characters which are not elsewhere found in this order, viz: the articulation of the fibula with the calcaneum, and the absence of the vertebrarterial canal. The former belongs to the *Artiodactyla* generally, and to the Proboscidæ, and the latter to the ruminant family of the *Camelidæ*. Thus the *Macraucheniidæ* stand out as one of the most distinct of the families of the *Perissodactyla*, and one to which we may anticipate considerable accessions in future.

But two species of *Macrauchenia* are known, a larger, *M. patachonica*, and a smaller, *M. baliviensis*, both from the Pliocene formation of South America.

PALÆOTHERIIDÆ.

This family has been already defined on page 378. In its complex premolar teeth, which in the upper jaw resemble the molars in composition, it shows an advance over the *Chalicotheroid* and other genera of the Lower Eocene. In fact, it has not been found in the Lower Eocene, but commences in the Upper Eocene in the genera *Palæotherium* and *Paloplotherium*. Thence it extends to the very summit of the Miocene, and may even occur in the European Pliocene (*Protohippus*). Its members exhibit considerable range of variation in the details of the teeth and feet, but no striking break of family importance occurs. The most noteworthy interruption is that which is found between the *Palæotherinæ* and *Hippotheriinæ*, where there is a change in the form of the proximal extremity of the humerus from a tapiroid to a horse-like form, and a modification of similar significance in the molar teeth, by the addition of a deposit of cementum.

The characters of the genera are as follows :

I. *Palæotheriinæ.* Bicipital groove of humerus simple ; teeth without cementum.

a. One or more internal tubercles of superior molars distinct.

External Vs of superior molars not well distinguished externally......... *Anchilophus.*

External Vs separated by a vertical rib ; intermediate tubercles not connecting fore and aft................................ *Paloplotherium.*

External Vs separated ; intermediate tubercles extended fore and aft...... *Anchippus.*

aa. Internal tubercles of superior true molars continuous with the transverse ridges.

Inferior molars with two Vs only; lateral toes large......... *Palæotherium.*

Inferior molars with distinct internal tubercles ; lateral toes small ; a short fifth metacarpal... *Mesohippus.*

Inferior molars with cusps at the inner extremities of the Vs ; lateral toes small; no fifth metacarpal.......................... *Anchitherium,*

II. *Hippotheriinæ.* Bicipital grooove of humerus double; molars with cement in the valleys. (Intermediate tubercles connected fore and aft.)

a. One or more internal tubercles of superior molars distinct.

Inner lobes of inferior molars enlarged..................... *Hippotherium.*

aa. Internal tubercles of molars not distinct.

Inner lobes of inferior molars enlarged...................... *Protohippus.*

The genera of this family are generally of less antiquity than those of the *Chalicotheriidæ*, and they range from the Middle Eocene to the Pliocene. *Paloplotherium* is found in the Middle Eocene, and is, as might have been anticipated, more nearly allied to the *Chalicotheriidæ* than any other genus of this family. *Propalæotherium* is not far removed from it. *Anchilophus* is upper Eocene, and is allied to the genus just named, and also to *Pachynolophus* among the *Lophiodontidæ*. These early genera constitute by their similarity, the bond of connection between the three families which in their later and specialized forms are very different from each other. *Palæotherium* is chiefly found in the Upper Eocene, and *Mesohippus* is only known from the White river or Oligocene, an age between Eocene and Miocene. *Anchitherium* commences in the Middle Miocene and has *Anchippus* for a cotemporary. *Hippotherium* existed only in the latter part of the Miocene Epoch, consistently with the greatly specialized structure of its limbs and teeth, and the nearly allied *Protohippus* lived with it; while in Europe a species with the same type of molar teeth is found in the Pliocene epoch (Forsyth-Major). These forms were cotemporary with the *Equidæ*, which outlived them. They have many points of resemblance to that family, but nevertheless remain at a considerable interval from them in the structure of the feet.

The geographical distribution of these genera, so far as at present known, is as follows:

North America alone—*Mesohippus*, *Anchippus*.

North America and Europe—*Anchitherium*, *Hippotherium*, [illegible]

Europe only—*Anchilophus*, *Palaeoplotherium*, *Palaeotherium*.

EQUIDÆ

The two genera of this family are distinguished as follows:

Internal lobes of superior molars crescentic........................ [illegible]

Anterior internal lobe of superior molars much larger than the posterior .... [illegible]

The genus *Hippidium* is extinct, and its species have been found in beds in North and South America in beds of Pliocene age. *Equus* made its appearance during the same period, and is represented by seven living species.

Besides the reduction in the number of digits, which is carried further than in any other family of *Mammalia*, there are several other characteristics of specialization. Thus in the dentition the [illegible] between the tubercles are filled with cementum. These valleys are generally deep, [illegible] in the prismatic forms of the molars. The cups of the incisors are completely developed and also filled with cementum. There are two [illegible] grooves of the humerus. The preceding characters are also seen in *Hippotheriinae* of the *Palaeotheriidae*.

The *Equidae* add another evidence of greater specialization than the latter group in the structure of its feet, i. e. the distal metapodial keel is complete forwards as in most ruminants.

The similarity of the modifications which have supervened on the Artiodactyle and Perissodactyle lines in attaining their most specialized forms has often been noticed. I repeat them here in tabular form in three columns. These show (Table I) the modifications in which the *Equidae* and *Bovidae* are identical or nearly so, which place them at the heads of their respective orders; Table II, those in which the *Equidae* are the more specialized of the two; and Table III, those in which the *Bovidae* display the highest differentiation.

	Table I.	Table II.	Table III.
1	Obliteration of first premolars.	Cupping of incisor teeth.	Absence of superior incisors.
2	Selenodont and prismatic character of molars.	Deposit of cementum in teeth.	Trough-shape of odontoid.
3	Flattened odontoid process.	Double bicipital groove of humerus.	Greater involution of lumbar prezygapophysis.
4	Reduction and coössification of ulna.	Reduction of metapodials to one.	Fibular articulation of calcaneum.
5	Intertrochlear crest of humerus.		Distal ginglymus of astragalus.
6	Distal facets of radius.		
7	Involution of lumbar prezygapophyses.		
8	Elongate sacrum.		
9	Shaft of fibula atrophied, and its distal extremity coössified to tibia.		
10	Reduction in number of digits.		
11	Anterior extension of carinæ of metapodial bones.		

The geographical distribution of these genera, so far as present knowledge shows, is as follows:

North America alone—*Mesohippus*, *Anchippus*.

North America and Europe—*Anchitherium*, *Hippotherium*, *Protohippus*.

Europe only—*Anchilophus*, *Paloplotherium*, *Palaeotherium*.

EQUIDÆ.

The two genera of this family are distinguished as follows:

Internal lobes of superior molars subequal .... *Hippidium*.

Anterior internal lobes of superior molars much larger than the posterior .... *Equus*.

The genus *Hippidium* is extinct, and its species have been thus far found only in North and South America, in beds of Pliocene age. *Equus* made its appearance during the same period, and is represented by several existing species.

Besides the reduction in the number of digits, which is carried farther here than in any other family of *Mammalia*, there are several other characteristics of specialization. Thus in the dentition, the spaces between the tubercles are filled with cementum. These valleys are generally deep, owing to the prismatic forms of the molars. The cups of the incisors are completely developed, and also filled with cementum. There are two bicipital grooves of the humerus. The preceding characters are also found in the *Hippotheriinæ* of the *Palæotheriidæ*.

The *Equidæ* adds another evidence of greater specialization than the latter group in the structure of its feet, *i. e.*, the distal metapodial keels are completed forwards, as in most ruminants.

The similarity of the modifications which have supervened on the Artiodactyle and Perissodactyle lines in attaining their most specialized extreme has often been noticed. I repeat them here in tabular form in three columns. These show (Table I) the modifications in which the *Equidæ* and *Bovidæ* are identical or nearly so, which place them at the heads of their respective orders; Table II, those in which the *Equidæ* are the more specialized of the two; and Table III, those in which the *Bovidæ* displays the highest differentiation.

	Table I.	Table II.	Table III.
1	Obliteration of first premolars.	Cupping of incisor teeth.	Absence of superior incisors.
2	Selenodont and prismatic character of molars.	Deposit of cementum in teeth	Trough-shape of odontoid.
3	Flattened odontoid process.	Double bicipital groove of humerus.	Greater involution of lumbar prezygapophysis.
4	Reduction and coössification of ulna.	Reduction of metapodials to one.	Fibular articulation of calcaneum.
5	Intertrochlear crest of humerus.		Distal ginglymus of astragalus.
6	Distal facets of radius.		
7	Involution of lumbar prezygapophyses.		
8	Elongate sacrum.		
9	Shaft of fibula atrophied, and its distal extremity coössified to tibia.		
10	Reduction in number of digits.		
11	Anterior extension of carinæ of metapodial bones.		

Note on the Structure of the Posterior Foot of Toxodon. By E. D. Cope.

The position of the genus *Toxodon* in the system of Mammalia, is a question upon which few authorities have expressed positive opinions, and which is generally regarded as still an open question. In the lack of certainty on the subject, a separate order, the "*Toxodontia*," has been proposed for its reception. It is known that the genus is ungulate, but the opinions of authors are much divided as to its relations to the three principal orders included under that head. Resemblances to the *Proboscidea* have been detected, but Professor Gervais (Comptes Rendus, 1878), asserts that there is a close resemblance to the genus *Hippopotamus* in the structure of the posterior foot.

Having come into possession of remains of *Toxodon*, which include the greater part of the skeleton, I make a few observations on the affinities suggested by the posterior foot, the only portion just now accessible in my collection. The calcaneum and astragalus have been more or less imperfectly figured by De Blainville and Burmeister, but no one has, to my knowledge, represented the entire foot. The calcaneum is rather short and stout, and its external convex tuberosity is of unusual size. Its articular surface is divided into two subequal parts, the internal of which supports the astragalus, the external the fibula. Thus the fibular articulation is of unusual size. The cuboid facet is on the inferior face of the extremity of the calcaneum, thus looking directly downwards when the bone is prone. In order to articulate with the remainder of the foot, the calcaneum must have been inclined upwards and forwards at an angle of 45°, and the cuboid inclined downwards and forwards at a similar angle. That the axis of the astragalus had the latter inclination is proven by the fact that the superior plane of the sustentaculum lies at that angle to the axis of the remainder of the calcaneum. The great convexity of the external tuberosity for the astragalus will also permit of such a position for the astralagus. The navicular facet of the astragalus is plane and truncates the bone somewhat inferiorly as well as distally, so as to present in the same way as the cuboid. There is probably no cuboid facet. I have not seen the cuneiform bones. The metatarsals and phalanges are robust and rather short. The distal keels of the former are posterior and rudimental. Their proximal extremities have a small lateral tarsal facet as well as the principal one. The median digits are of unequal length, and the lateral ones are much shorter, but robust. Whether there are four or five digits I cannot definitely ascertain.

The above characteristics are very significant. They at once refute any supposition of affinity to the *Artiodactyla*, whether suilline or ruminant. The form of the astragalus and wide fibular condyle of the calcaneum, opposes the reference of the genus to the *Perissodactyla*. On the other hand, all the characters of the feet thus far adduced, are found in the *Proboscidea*. They are not only those of that order, but they are carried to a degree of exaggeration, as though *Toxodon* represented a high grade of

specialization of that order. The posterior feet were more truly plantigrade, for the extremity of the calcaneum reached the ground, while the instep was elevated above it, being supported, no doubt, by a more or less elastic pad. This arched or angulate plantigrade type of foot, has a remote parallel in that of man. It is quite unique among ungulate *Mammalia*.

What difficulties the other parts of the skeleton may present, I do not yet know, but I perceive nothing in the dentition which forbids the reference of *Toxodon* to the *Proboscidia*. The dentition is scarcely more different from that of *Mastodon* or *Dinotherium*, than that of *Bos* is from *Dicotyles* or *Hippopotamus*. The former genera may be the extremities of a series whose intermediate members are as yet undiscovered. In the latter case, the intermediate forms are mostly known.

Stated Meeting, May 6, 1881.

Present, 22 members.

President, Mr. FRALEY, in the Chair.

Capt. McCauley and Mr. Ellis Yarnall, two newly-elected members were introduced to the presiding officer and took their seats.

Visitor, Lieut.-Commander Gorringe, U. S. N.

Letters acknowledging receipt of diplomas were received from Messrs. W. B. Taylor, C. P. Patterson, Asaph Hall, J. J. Stevenson, C. F. Adams, J. F. Mansfield, A. S. McCreath, J. Douglas, Jr., L. M. Haupt, R. H. Alison, O. W. Holmes, Alvan Clark and J. J. Sylvester.

Letters accepting membership were received from Mr. Alvan Clark, dated Cambridgeport, Mass., April 25th; Prof. J. J. Sylvester, dated Baltimore, April 25th; Judge Wm. Butler, dated Philadelphia, May 6th; Prof. E. A. Barber, 4101 Walnut street, Philadelphia, April 25th, and Mr. W. W. Griscom, 2009 Pine street, Philadelphia, April 18, 1881.

Letters of acknowledgment for publication, and letters of envoy were read from the Musée Guimet, Herr Sommerbrodt, of Breslau, April 11th, 1881; the Physico-Central Observatory, St. Petersburg, the Smithsonian Institution, April

15th, and the Bureau of Ethnology, J. W. Powell, Director, April 25th.

Donations for the Library were received from St. Petersburg Botanical Garden; Swedish Bureau of Statistics; Dr. Julius Sommerbrodt, of Breslau; R. Belgian Academy; Geographical Society, of Bordeaux; Revista Euskara, of Pamplona; R. Academies at Turin and Rome; R. Astronomical Society; Society of Antiquaries; Dr. C. W. Siemens; Augustus Mongredien; London Nature; Hon. R. C. Winthrop; Boston Academy; American Journal of Science; American Philosophical Association; Essex Institute; American Antiquarian Society; Harvard University Bulletin; Samuel H. Scudder; Astor Library; Microscopical Journal; James J. Talbot; Geol. Survey of New Jersey; Penna. Magazine, Engineer's Club, Franklin Institute, Pharmaceutical Association, Prof. E. A. Barber, Numismatic Society, Penna. Hospital for the Insane, Penna. Museum and School of Industrial Art, Am. Journal of Pharmacy, Medical News, Prof. L. M. Haupt, Mr. Henry Phillips, Jr.; Maryland Historical Society; Smithsonian Institution, Anthropological Society; War Department; Hon. W. D. Kelly; Mr. Jed. Hotchkiss; Mr. Chas. C. Jones, of Savannah; Wisconsin Nat. History Society; Ministerio de Fomento.

The death of Prof. A. Delesse, at Paris, March 24th, aged 63, was reported.

Mr. Frazer exhibited coins; and also specimens of the granite, cement, lead, bronze and steel used by Egyptians in erecting the obelisk now in New York, and sections of the granite under the microscope.

On motion of Mr. E. K. Price, the thanks of the Society were voted to Lieut.-Commander Gorringe for the great gratification he had afforded the members, by the exhibition of many rare and valuable ancient coins of Egypt, Macedonia, Greece and Rome; and to Mr. D. S. Holman for his assistance in rendering them visible to all by his megascope.

Mr. Ashburner exhibited a suite of maps of one of the British coal fields.

Dr. Chance communicated a paper entitled "An analysis of the Fire-damp Explosions in the Anthracite coal mines, from 1870 to 1880."

Mr. Fraley reported that he had received the last installment of the Michaux legacy, amounting to $131.18, and, paid it over to the Treasurer.

And the meeting was adjourned.

An Analysis of the Fire-damp Explosions in the Anthracite Coal Mines, from 1870 *to* 1880. *By H. M. Chance, M. D.*

(*Read before the American Philosophical Society, May* 6, 1881.)

The table which forms the subject matter of this paper is compiled from the reports of the Inspectors of Mines, for the years from 1870 to 1879 inclusive. In it are included all recorded explosions, whether resulting in serious or trivial casualties. The majority of these were caused by the ignition of but a few cubic feet of explosive mixture, but some were terrible disasters, the victims of which may be numbered by scores.

The total number of recorded explosions is 689, the number of casualties 1137, and of these 225 resulted fatally. As the reports for two or three years are not complete, these figures do not represent the exact number of casualties; but they express sufficiently well the ratio between the explosions and the number of miners injured by them.

During these years the explosion of fire-damp was the cause of sixteen per cent. of the total casualties reported by the Inspectors, of eleven per cent. of the fatal accidents and of eighteen per cent. of the non-fatal casualties.

Explosions of Fire-damp.

	1870.	*1871.	1872.	1873.	1874.	†1875.	‡1876.	1877.	1878.	1879.	Total.
January....	0	8	3	2	2	3	5	7	2	4	36
February....	2	4	4	2	5	3	6	4	1	5	36
March.....	0	2	6	3	3	3	4	5	0	8	34
April......	4	7	14	6	5	2	7	8	2	10	65
May.......	3	10	8	9	8	1	11	9	2	18	79
June......	1	6	7	13	12	5	4	6	4	3	61
July......	3	11	5	4	7	7	2	7	4	6	56
August.....	3	10	13	10	5	3	2	3	6	9	64
September...	4	9	6	10	9	12	4	2	0	10	66
October.....	8	7	10	6	8	6	8	7	2	10	72
November....	6	3	2	7	9	5	4	7	2	7	52
December...	6	6	3	2	4	9	8	6	4	10	58
Total....	40	83	81	74	77	59	65	71	29	100	679

* Explosions in Eastern District of Luzerne, not included in the report for 1871.

† Explosions in Southern District of Carbon and Luzerne, not included in column for 1875.

‡ Shamokin District statistics omitted from report for 1876.

The table is arranged to show the number of explosions occuring in each month of the year for ten years, and the right hand column the number for each month of the whole period.

An inspection of latter column shows at once that from April to October the number of explosions is far greater than that of the remaining months of the year. In these seven months 463 explosions are recorded, an average of sixty-six for each month, but for the remaining five months (Jan., Feb., March, Nov. and Dec.) we find but 216 explosions, an average of but forty-three for each of these months.

Temporary or partial suspension of mining during some part of these months in certain years may partly account for this difference, but is inadequate to explain so marked a contrast between the groups of warm and cold months.

It seems probable, that if a closer differentiation could be made, it would be found that many of the explosions occurring during the warm months, happened at or immediately following a short period of unusual warmth, during which the ventilating current was somewhat diminished in strength. At such a time, when unusual warmth with high barometer had existed for one or two days, a sudden fall in the barometric column, presaging a local or general storm would surely be followed by an increased outflow of gas which might readily become explosive at the working face while the air still remained safe in the upcast.*

The low rate of July may be due in part to partial suspension of operations during that month, and the high rates of November and December, high compared to those of January, February and March, are probably due in part to steady working to supply the winter demand, and the low rates of the remaining winter months to partial suspension of work.

The maximum rate in May, and the next in rank, October, are just five months apart. Are these months subject to greater and more sudden and frequent barometric changes than others in this part of the United States?

A list of the most serious colliery disasters in Great Britain, from 1778 to 1866 inclusive, develops the interesting fact that out of forty-five explosions, ten occurred in June and eight in December, periods just six months apart.

The table is as follows:

Months.	*No. of Explosions.*
January	2
February	1
March	4
April	0
May	4

* If one per cent. of gas in the upcast corresponds to a maximum of five per cent. at the working face (in places where "accumulations" are found) an increase of two per cent. in the upcast, making three per cent. in all, a perfectly safe percentage—means an increase to seven per cent. at the working face; a condition of great danger. The above described meteorological conditions may often bring about just such a result.

Months.	*No. of Explosions.*
June	10
July	4
August	8
September	2
October	4
November	8
December	8
Total	45

This list embraces only the explosions resulting in great loss of life. The minimum loss of life was 20, and the maximum, the Oaks Mine disaster, December, 1866, was 362; the loss of life aggregates 2621, an average of more than 58 for each disaster.

The occurrence of three of these explosions on June 2, 1862 (at Washington, Guindræth and Coppal), and two of the most fatal on December 12th and 13th, 1866 (the "Oaks" and "Talk o' the Hill"), by which 362 and 92 lives were lost, certainly point to atmospheric disturbance as the immediate cause. The occurrence of a large percentage of these disasters at semi-annual periods, June and December, seems to indicate the occurrence (in Great Britain) during these months of unusually high barometer, followed by a decided fall, as the probable cause of these great outbursts of gas.

But the problem I have been considering is somewhat different, for the table embraces *all* the explosions, whether large or small, occurring during the ten years. Is shows a decidedly larger number for the warm than for the cold months, and therefore points primarily rather to impairment of ventilation from high temperature than to barometric changes as the true cause of the difference; but the occurrence of two maximum periods, May and October, seems to indicate that barometric changes have also exercised an important influence on the relative efflux of gas.

The *amount* of rise and fall does not seem to have a perceptible effect, for the monthly barometric range is *greatest during the cold months*, whereas fire-damp explosions are most frequent during the warm months. Frequent and *abrupt* changes from high to relatively low barometric pressure, are the probable cause of many explosions, though the movement of the mercury may not amount to more than one-eighth or one-quarter of an inch. An unusually *high* barometric column is always an intimation of coming danger.

Stated Meeting, May 20, 1881.

Present, 5 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from E. Malézieuz, dated Paris, March 4th; from Claudio Jannet, 38 Rue de Varennes, Paris, May 7th; and from Paul Leroy Beaulieu, Paris, 27 Avenue de Bois de Boulogne, May 4th.

A letter acknowledging diploma was received from J. Ericsson, dated New York, May 14th.

A letter of envoy was received from the Royal Geological Society of Cornwall, May 3d, 1881.

Donations for the Library were received from the Royal Prussian Academy; the Botanisches Centralblatt, Kassel; Zoologischer Anzeiger; the Geographical Societies in Paris and Bordeaux; Editors of the Revue Politique; Revista Euskara; the Journal of Forestry, London; Royal Geological Society of Cornwall; Essex Institute, Salem, Mass.; Museum of Comparative Zoology, Cambridge; Boston Society of Natural History; Young Men's Association, Buffalo; Mr. A. R. Grote, Buffalo; Zoological Society and Franklin Institute, Philadelphia; U. S. National Museum, Washington; American Antiquarian, Chicago; Kansas Historical Society, Topeka; Revista Cientifica Mexicana, and the Ministerio de Fomento, Mexico.

Mr. Price presented in the name of Mrs. Ellen Keene Mitchell a certificate of membership of John Lukens, dated the 20th day of January, 1786, and signed by the officers. John Lukens was Surveyor General of Pennsylvania from December 17th, 1761, until his death in October, 1789. Mrs. Mitchell is his lineal descendant.

On motion of Mr. Price,

Resolved, That this Society present their thanks to Mrs. Ellen Keene Mitchell for the certificate of membership in this Society of her ancestor, John Lukens, Surveyor General of Pennsylvania, dated the 20th January, 1786, signed by the officers of that date.

Mr. Lesley showed a translation of the Lord's Prayer into Egyptian hieroglyphics by Commander McCauley, U. S. N.

Pending nominations No. 934, 935, 936 were read.

The proceedings of the last meeting of the Officers and Council were submitted.

The meeting was then adjourned.

Notes on an Egyptian element in the Names of the Hebrew kings, and its bearing on the History of the Exodus. By *J. P. Lesley.*

(*Read before the American Philosophical Society, March* 4, 1881.)

It was accounted a great discovery when, a few years ago, papyri were found stating the number, cost and transportation of squads of APURU from the Delta to the mining districts in Nubia. These official documents were a sort of Indian bureau agent reports of the age of the XIX Dynasty, say 1400 B. C.; and therefore the word APURU was suspected of being the Egyptian equivalent of the Hebrew word עברים, OBRIM, Hebrews.*

Gesenius gives some good reasons for the common etymology of the word from the verb OBR, 'ăvăr, *to pass.*†

It occurs in Chaldee as Eber, "the country beyond" the Euphrates. And therefore the LXX translates "Hebrew" in Gen. 14 : 13, by ὁ περάτης, the *immigrant* or *emigrant.*

The Biblical usage of the word seems to be restricted to cases when foreigners were speaking of the Israelites, Gen. 39 : 14, 17, &c.; or when Israelites were speaking of themselves to foreigners, Gen. 14 : 15, &c.; or when some opposition to foreigners is in question, Gen. 43 : 32, &c. It seems, however, rather absurd to put the word with this meaning into the mouth of the Hebrews themselves. One can very well imagine them calling surrounding extra-limital tribes "outsiders," "people over there;" but to imagine them accepting such a title as their own, contravenes all that we know of their proud and exclusive estimate of themselves, unless these sentiments be considered a product of later times.

The difficulty is enhanced by the fact that, whereas in Gen. 50 : 10, 11; Deut. 1 : 1, 5; 3 : 8, 20, 25; 4 : 41, 46, 47; Josh. 1 : 14, 15; 2 : 10; 9 : 10;

*The pronunciation of the word by the Masorites, after the time of Christ, 'IVRIM, is of no importance, except as indicating the probable guttural aspiration of the ע, by which the Greeks were lead into writing the word Ἑβραιοι, Hebraioi.

†This root is widely distributed, as in the english *over*, german *über*, latin *super*, greek '*ubris* (pride), *upper*, and to *pour*, *outpouring* (overflowing or passing bounds).

12 : 1; 13 : 8, 32; 14 : 3; 17 : 5; 20 : 8; 22 : 4; Judg. 5 : 17 and Isai. 8 : 23, the root עבר *beyond* is applied to the Gilead and Bashan (east) side of the Jordan, it is applied in Josh. 5 : 1; 9 : 1; 12 : 7 and 1 Chron. 26 : 30 in directly the opposite way, to the Ephraim and Judah (west) side of the Jordan.*

The only plausible explanation comes from the fact that the tribes settled to the east and to the west of the Jordan spoke of each other as *beyonders;* and the song of Deborah shows in how bitter a spirit the epithet could be employed; while the address of Jepthah (the Gileadite) seems to ignore the tribes on the west side altogether, as if they were not Israelites.

If the theory be tenable that the Abrahamidæ or Terahites migrated towards Palestine not from the direction of Kurdistan and Assyria, but from Babylonia, by way of Yemen, up the east coast of the Red Sea, through Midian, into Edom and Moab, long before the Exodus, it follows that they would be recognized by the Horites or troglydites (*Hor*, a cave) of Petræa, as "foreigners" (Hebrews), and might possibly be compelled by circumstances to accept the epithet.

If part of this migration was represented by the Kenites, and if Moses himself was the son† of the Kenite Scheik Jethro‡ and was sent by him to bring another enslaved part of the migration, back, over the desert, to their comfortable settlements in Petræa,—then it becomes probable that the name "Hebrews" is merely a patronymic for *Beni Hêber*, the descendants of Heber the (original) Kenite.

Gesenius long ago wrote: "Heber, the founder of the Hebrew race, Gen. 10 : 24, 25; 11 : 14, 15," and referred to the expression *Beni Heber* in Gen. 10 : 21, and the poetical expression *Heber* (Hebrews) in Num. 24 : 24.

The LXX spells Heber, Ἑβερ, and Ἐβερ. He was son of Salah and father of Peleg (the Philistines). The Jews have always considered him their national patronym. The Heber of Judges 4 : 11, 17; 5 : 24, is spelled differently, חבר, LXX χαβερ, *Chaber*, and he must have lived a century or two *after* Moses; for he was a descendant of Hobab, son of Jethro and brother-in-law of Moses. Many changes had occurred. The Kenites were amalgamated with the other Hebrew tribes; and this wealthy sheik, Heber, who had married Jael, lived in the extreme north of Palestine, and was a friend of the King of Damascus. The rough spelling of his name suggests a northern patois.

In the word *Ephraim*, then, we may have merely another dialectic spelling of the word *Ebraim* (Hebrews.) It is written in our Hebrew texts אפרים, APRIM, and is a sufficiently precise reproduction of the APURU of the papyri. As the latins nasalized their final M, and ignored it in scanning, so the Hebrew plural final *im* would disappear in Egyptian, and be replaced by the regular Egyptian plural termination U.

* *Beyond* the Arnon, *beyond* the sea, and *beyond* the river (Euphrates?) are also expressions in use.

† Son-in-law.

‡ The same as, or the son of Raguel, "friend of God."

If Egyptologists be now inclined to reject the APURU=OBRIM (Hebrew) theory, they can hardly have reason to reject an APURU=APRIM (Ephraim) theory, if it were suggested; and the object of these notes is to suggest it, with the grounds for its consideration; not, however, on the side of Egyptian philology, but on the side of Hebrew history.

A recent anonymous work on "The Hebrew Migration from Egypt" (London, 1879), draws attention to the fact that the account of the Exodus collates two distinct stories from different sources, in one of which the term *Israelites* only, and in the other the term *Hebrews* only, is applied to the emigrating people; and that one of these stories speaks also of a "mixed multitude" forming a separate part of the emigration.*

Jacob represents the Hebrew race in the traditions of Judah and the south; Joseph represents the Hebrew race in Egypt; Ephraim in the history of the northern division; and Reuben in that of the transjordanic provinces. The distinction between the *Beni-judah* and *Beni-israel* pervades Palestinian literature from first to last. It is plain to see that some stirpal barrier divided the northern from the southern parts of the country, and that they were never united except during the short dynasty of David and Solomon. Judah was not Israel, and never had been. Ephraim alone was Israel. "To your tents Oh, Israel; what part have we in David . . . so *Israel* departed unto their tents. But over the *Beni-Israel*, who lived in the cities of *Judah*, Rehoboam continued to reign." His own people were not Beni-israel, but "*men of Judah*."

If the children of Israel then were Hebrews and not Jews, and if Ephraim was practically Israel,† the exclusive and specific use of the term *Hebrews* in the story of the Exodus practically confines the history of the exodus to the *Beni-joseph*, the descendants of Ephraim and Manassah.

But the name *Manassah* is not a Hebrew but an Egyptian word; while the name *Ephraim* is par excellence a Hebrew word. There is a strong probability then that while Ephraim meant the Hebrew division of the emigration, Manassah meant the "mixed multitude," partly Egyptian and partly perhaps Kenite, Midianite, or what not.

The word *Manassah* reappears in Hebrew history, after the lapse of 500 years, as the name of a king of Judah (not of Israel); and evidently not as a survival of what had been a common personal or family name, but as an Egyptian name; for, it comes to view in company with other Egyptian names, and in consequence of the alliance of Solomon with a reigning Pharaoh, whose daughter he made his queen, or first lady of the harem. His other wives were princesses of surrounding Shemitic tribes. Their children were baptized with Shemitic names; but *her* children probably received Egyptian names.

*A short resumé of the whole book is given in the 15th or last chapter. Whatever the author might think of the suggested connection of *Hebraim* and *Ephraim*, cannot be said. It certainly fits into his exegesis.

†The rest of the tribes (except Levi) play a curiously subordinate rôle in the whole story; are dropped out of it early, and are scarcely even incidentally mentioned afterwards.

After the crown of Solomon had descended to the Shemite Rehoboam (whose mother was Naamah the Ammonite), the Pharaoh Sheshonk (Shishak) looted Jerusalem, in the cause of his (Shishak's) protégé, Jeroboam of Israel.

Jeroboam's wife *Maachah* carried an Egyptian name; she was the daughter of Abishalom (father of peace), a Shemite, who had probably married an Egyptian girl, perhaps one of those bred at Solomon's court.

Abijah, Jeroboam's son and successor, had a pure Shemite name, if the priestly Judean chronicler (2 Chron. xiii, 1) spells it rightly; for it means "My father Jah." It has a variant, *Abijahu*, meaning "whose father is Jah."

The Judean historian of 1 Kings (xv. : 1, &c.), always spells it *Abijam*, which should mean in Hebrew "My father the sea;" but Gesenius translates it "Father of the sea; *vir maritimus*;" the sailor.

Without the points these two forms read simply ABIE (LXX ἀβιά) and ABIM (LXX ἀβιού). The first form is anticipated in Abiah ABIE (LXX again ἀβιά) one of the sons of Samuel (*pater Jehovæ, vir divinus, i. q. ish elohim*, Ges. !)—and again in *Abihu*, ABIEUA, (LXX ἀβιούδ) second son of Aaron. The absurd and only (Hebrew) etymology suggested for this name is "Father of him," "to whom He (God) is father." Nothing can be more forced and improbable.

It is very significant that, of the four sons assigned to Aaron, viz., Nadab, Abihu, Eleazer and Ithamar, two of them, Nadab and this *Abihu*, were struck dead "for offering strange fire," that is, for worshiping Jehovah according to some foreign rites, doubtless Egyptian.† The הוא (HUA) final in Abihu's name is so strongly pronounced that it must have some signal significance, and it suggests the $a\chi u$ sphynx god of the horizon. If Abijah be My father Jah, *Abihua* is *Father Axu*.

Moses' name is acknowledged to be pure Egyptian. *Aaron's* name is as positively Egyptian as evidence can make it; for ARN is the most sacred name for the ark, box, ship of Isis, sarcophagus, &c. And there is no good reason to be urged against an Egyptian etymology of the name of Aaron's tenth descendent, the high priest *Abiathar*, ABIThR (LXX 'ἀβιάθαρ) from the goddess *Athor*, or Hathor, "the habitation of Horus," meaning *the temple*, or shrine. *Abiathar* would then mean simply the "father," or "guardian of the shrine."

*This is a mere confession of etymological desperation; and casts discredit on the whole series of names beginning with Ab and Abi. One might just as well propose to derive the Hebrew word אביונה *Abijonah*, "desire, appetite, lust," also "the berry of the caper bush" (thought to be provocative of lust) from Abi and Jonah—"Father of Jonah," or "whose father is Jonah." So, some have asserted that *Abihud* (1 Ch. 8: 3) must have meant "whose father is Judah;" *Abigail* "whose father is joy," *Abidan* (Num. 1: 11), "father of the judge," although he was himself a judge; &c. Only when a name is clearly written out (like *Abiezer* אביעזר, "father of help," *i. e.*, the beneficent), can these etymologies be considered probable.

† Compare the Apis rebellion conducted by Aaron, for which he also perished.

To return now to the Kings of Judah; *Abijah* or *Abijam* walked in all the sins of his father, that is, did *not* worship Jehovah; or, at least, worshiped other deities also.

Asa, son and successor of Abijam, had one of the purest of Egyptian names; a name borne by the Fourth Pharaoh of the Fifth Dynasty, called "the good *Assa*," and by the Eighth of the same dynasty, called simply "*Assa*," with the forename *Tatkara*. The word meant, in Egyptian, image or statue. Queen Hatasou called the temple she built to Hathor, *Assassif*.

It is an odd but characteristic clerical error in 1 Kings xv, 10, that the scribe repeats of Asa what he had before said of his father, Abijah, that his mother (not grandmother) was *Maachah*, daughter of Abishalom. The chronicler (2 Ch. xi, 20) says that Maachah was Abijah's mother, and says nothing about Asa's mother. But he lets us into the state of Jehovah worship thus: Azariah went to meet Asa returning from a great victory over the Cushites, and said...."Jehovah is with you....*Now for a long season Israel* (*hath been*) *without the true God*, and without a teaching priest and without law....When Asa heard these words....he put away the abominable idols out of all the land of Judah and Benjamin....and renewed the altar of Jehovah," &c. The baby *Asa* might well bear a pure Egyptian name.

Jehoshaphat was the son and successor of Asa. Both he and his mother, Azubah daughter of Shilhi, have therefore Hebrew names; and he seems to have followed his father's faith in Jehovah, and to have been in fact a zealot, establishing a sort of colportage system throughout the south country, and appointing clerical judges (Shophetim) everywhere.

Jehoram, Jehoshaphat's son and successor, had six brothers; and all seven had honest Hebrew names. But Jehoram slew his six brothers; married Ahab's daughter; and let loose idolatry again in Judah. After a long and disastrous reign he is made to die, like the apostate Julian, of some horrible bowel complaint, as a punishment for his defection from Jehovah, and was refused burial in the royal tombs (an Egyptian punishment).

Ahaziah, son of Jehoram, reigned but one year, and was murdered by Jehu, the usurper of Israel. All his family were then destroyed by his mother, Athaliah, except little Joash, who was concealed by the high priest, Jehoiada, in the temple for seven years; and then a revolution placed him on the throne, which he rededicated to Jehovah.

Joash, is certainly Hebrew for *Theodore*, "God given." The name was borne not only by this eighth King of Judah, but also by the twelfth King of Israel, which secures its semitic character. His mother's name was Zibiah of Beershebah. After Jehoiada's death, this king plunged into the indulgence of all the popular idolatries; and among the violences which occurred were:—the famous stoning of the prophet Zechariah; the slaying of Jehoiada's sons; the victorious invasion of the Syrians; and the assassination of Joash.

Amaziah (a Hebrew name) succeeded to the throne. His mother was Jehoaddan of Jerusalem. He served Jehovah; defied Joash of Israel; was defeated and ruined, and afterwards assassinated. His piety towards Jehovah stood him as little in stead as did his descendant's, Josiah.

Azariah (*Uzziah*), his son, had a long, pious and prosperous reign of fifty-two years. Jecholiah of Jerusalem was his mother. He became a leper, and his son Jotham acted as regent.

Jotham's mother was Jerusha, daughter of Zadok (a priestly name), and he worshiped Jehovah, like his father. One would not expect anything non-semitic in his name, יוטם (IOThM), and it is probably rightly translated "Jehovah (is) upright;" but it is constructed precisely on the Egyptian plan in all those cartouches containing *nefer* and *tat*. It is an ancient name also, for it occurs in the history of the times of the Judges (9: 5) as the name of a son of Gideon (LXX γεδεων, גדעון, perhaps "tree-cutter," or impetuous warrior. Ges.).

Ahaz, his son, succeeded, and sent for Tiglath Pilezar to come and carry off the *Beni-Israel*. He sacrificed his own son to Moloch; and one is sorry not to find his mother's name recorded, for she was probably a foreigner, and gave him his name.

The curious thing about this word אחז, LXX 'αχαζ (Josephus 'αχαζης) in this case is, that it stands alone, pure and simple; whereas in the cases of *Ahaz*iah the sixth King of Judah, his direct ancestor, and *Ahaz*iah the seventh King of Israel, the word is joined to the name of Jah, "whom Jehovah sustains," exactly equivalent in sense to the Pharaonic *Ra-tat-ka*, 16th cartouche on the 2d tablet of Abydos, *Sol sustains life;* and *Ra-tat-f*, 32d cartouche on the same, *Sol his sustainer*.

Ahaz would represent the *tat* standing alone in the cartouche.

It is very remarkable to find *Asa* and *Ahaziah* connected in Judah, and *Assa* the Pharaoh of Egypt with the surname of *Tatkara*.

Ahaz reigned sixteen years, and seems to have been an exceedingly heathenish prince, respecting neither Jehovah, the priesthood, nor the prophetic schools. He closed the temple of Solomon. No wonder he dropped the Jah from the name which he inherited from his ancestor *Ahazjah* five generations back. Under his auspices the Phynicean Baal and Astarte-worship flourished, as it did at that time in the Delta of Egypt.

His politics, however, were not Egyptian. He called in to his aid, not the power of Egypt, but the army of Pul, King of Assyria, and became his vassal. In consequence, Pul's successor, Tilgath Pilezar, added Gilead and Galilee to his empire, wiping out the true *Children of Israel* from the Promised Land. The hoarded wealth of Judah was the price paid for a merely nominal security against the same fate. From this date of Ahaz's reign in Judah we hear no more of Ephraim; the lands of which were now crowded with forced colonists from Mesopotamia, bringing their languages and religions with them, and mixing these up with the Hebrew language and the worship of Jehovah.

Hezekiah followed Ahaz on the throne of Judah, and reigned twenty

nine years. His mother, Abi (*my father*), was evidently a Jewess, the daughter of a Jew, Zakariah. She gave her son a genuine Hebrew name, HZQ-IE, חזקיה, "the strength of Jehovah;" for she was a zealous worshiper of the true faith, and reared her son in its rigid observance. The verb חזק (hazk) means to bind, hold fast, adhere, cleave to, make firm, strengthen and be strong. In this secondary sense it agrees with the Egyptian *Tat*, and illustrates the construction of such royal names. But it can have no direct connection with Egypt; for it is amply explained by the Hebrew primary sense of the word as used in speaking of fortifying a city, &c.

His name characterized the prince. He was the great reformer of Israel. He, in fact, created the Jehovah cultus in Judæa; he cleansed the temple; restored the service; destroyed idol worship out of the land; and was carried by his iconoclast zeal so far as to break to pieces and cast away beyond redemption the brazen serpent of Moses, preserved for centuries as a divinely precious relic and evidence of the exodus in the temple of Solomon. His sacrifices to Jehovah were on the most magnificent scale; and his restoration (if we may not call it his *invention*) of the great festivals made the whole people zealous for the law.

The Passover now first became national; and by the total destruction of all high places, Jerusalem became at last the only centre of convocation, and Mt. Moriah the only place of worship in the land.

He then reconquered the lost provinces of David's kingdom from the Philistines, and contracted an alliance with Egypt against Sennacherib, Emperor of Assyria. But he had to buy off the latter with all his spare treasures. By some unexplained accident Sennacherib's army was destroyed and Judah saved. On this being known, Hezekiah received a congratulatory embassy from his fellow-sufferer, Merodach Baladan, King of Babylon.

On the occasion of his hospitable and rather ostentatious reception of this embassy, the prophet Isaiah was greatly scandalized; so, at least, long subsequent chroniclers report.

The rest of his life was peaceful, and Judah became again prosperous. A reservoir was constructed west of the city, and conduits for a larger and more regular water supply added.

Man-asseh followed his father Hezekiah.

This pure Egyptian name follows immediately a pure Hebrew name; and, Idolatry follows immediately the most zealous Jehovahism. How is this to be accounted for?

Manasseh's mother's name was *Hephzibah*, חפצי־בה, *My delight is in her.* This is the poetical name given by the Second Isaiah (62 : 4) to *Zion*, and explains its own meaning. It may have been a term in popular use, taken from the young and beautiful queen of the pious King Hezekiah and applied to Jerusalem. Or, *vice versa*, Hezekiah may have endowed his wife with this pet name in reference to his own delight in Jehovah's delight in his (Hezekiah's) temper and work. But in any case Hephzibah

must have disappointed her husband's pious expectation; for, her son Manasseh was a Jehovah hater; reversed all his father's arrangements; reestablished idolatry; erected altars to the solar and lunar deities in the courts of the Temple; degraded the priesthood, and slew the prophets.

Hezekiah's policy had been to ally himself with Egypt against Syria. It was unsuccessful, and he was saved by a mysterious disaster to the Assyrian host while it lay encamped in face of an Egyptian army.

Hezekiah's alliance with Egypt was no doubt permanent.

Did he marry an Egyptian princess?

This is not said; but neither is Hephzibah's parentage given. The name Hephzi-bah is suspicious. It is capable indeed of a plain Hebrew etymology; but the main element in it *Hapz, favor, delight,* is an exact translation of the *most common element in all the Egyptian royal and princely names, Meri, beloved.* The great Ramses was surnamed *Meri-n-Ra, beloved of the Sun,* or the *Sun's delight,* which would be translated into Hebrew *Hephzi-shemesh.** And a hundred other royal Egyptian names and surnames are constructed by composition with this same elemental *Meri,* applied to various other deities, like *Meri-n-Ptah,* Ptal's delight; *Meri-n-hathor,* Hathor's delight, &c.† It would be even possible that Hephtzibah, HPZI-BE may mean *Be's delight;* were any deity known named BE.

* The 36th King of the 2d Tablet Abydos is *Ra-meri, Sun's delight.*

† When Alexander's conquest grecised the Egyptian court language, the Greek φιλος took the place of this *meri* in official titles, and in comparative philology is its phonetic equivalent.

The first Ptolemy Lagidos was called *Soter,* "the preserver," by the Rhodians, grateful for his assistance against Demetrius.

His son, born in Memphis, educated by men of Egyptian learning, builder of Arsinöe and Berenice, completer of the great canal, constructer of the great high road across the Thebaid, founder of the Ethiopian colonial entrepôts, and restorer of Egypt to its ancient glory, was glorified by the natives as their great patron of the ancient learning. His library possessed 400,000 rolls. Callimachus, Euclid, Aristarchus, Aratus, Theocritus, Apelles, Manetho illustrated his court, compiled history, taught science and translated the Hebrew Bible.

The Egyptians gave him or he gave himself the surname *Philadelphus,* to express his ardent love for Arsinöe, his sister (and wife). But surely such a name would not have been adopted except in a land, the ancient monarchs of which had so often compounded their surnames, on the same principle, with the word *Meri,* "loving," or "beloved of,"—and usually some divinity. Arsinöe was Ptolemy's goddess, as Hathor had been of many an older native Pharaoh.

Ptolemy III, Euergetes, received his surname from the Egyptian priesthood, in reward for bringing back to their proper shrines a multitude of divine statues which Cambyses had carried off to Persia. He also loved and married his own sister Berenice, and revenged an affront to her by conquering Antiochus Theos. King of Syria, and then extended his conquests to Bactria and India. "*Well done* good and faithful servant," cried the priests, "thou shalt henceforth be called by the name of the last and greatest Pharaoh of the most ancient days, *Snefra,* Euergetes, the beneficent, the well doer, the benefactor. He also patronized the ancient learning. (See Lauth's Manetho; and the Prisse papyrus I, Ch. 2. line, 8.)

Ptolemy IV, Philopater, could not have been so called (except in derision) from his filial piety, for he was supposed to have poisoned his father. This wretch who murdered his own mother, wife, sister and brother, was called by

And there was not only a god *Bast*, in the Egyptian pantheon, but a curious deity named BES, said in one of the texts to have come from Arabia. This god presided over women's toilets, dress and ornaments, and was the especial favorite of the Egyptian ladies. The final ה in Hephzibah's name is well known as the equivalent of the sibilant (ἁλς, sel, &c.) and *Hephzibah*, without any violence can be read *Hephzibes*. Her egyptian idolatry would then be not only pronounced, but natural and national.

There is no reason, then, for excluding solar and lunar proclivities from the characteristics of Manasseh's mother. Her son's practise would naturally revert to solar and lunar worship when he ascended the throne, which he did at the early age of six years (699 B. C.). For six years, at least, afterwards, he would be governed by the queen dowager and her friends; and by that time the religious reaction would have acquired stability. It is not surprising, then, that his diplomatic policy went wholly on Egyptian principles. The alliance which his father made with Egypt became still closer, and the story of the French restoration in 1815 was anticipated by the return of thousands of émigrés. These men, all of them devoted to Phœnician sun rites, and hating Jahvism, returned from exile at Memphis and San, Tyre and Sidon, hot with revengeful feelings against the orthodox cultus of Judæa, and charged with the religious sentiments prevalent among the vast Phœnician population of the Delta. It is not impossible that the name *Manasseh* was now first assumed by the young king as his banner name.

The supposition that the name was given him at circumcision, and that it was chosen because it had been borne by the eldest son of Joseph, and was one of the tribal names of Palestine, is improbable, 1. Because the tribes of Manasseh and Ephraim were hereditary enemies of the royal house of Judah, and 2. Because those two tribes had been deported to Assyria before this Manassah was born. It is *possible*, indeed, that *Manasseh* was a private name still in common use in the kingdom of Israel; but

the Egyptians *Typhon*, the devil; and by the Greeks *Gallus*, on account of his debaucheries, which brought his life to an end in its 37th year. But he paid great public honors to the *memory* of his father, and may have assumed the name Philopator, *Meri-n-tef*, as part of the hypocrisy.

Ptolemy V, coming to the throne at 4 years of age, and to the government at 14, assumed the title *Epiphanes*, the illustrious, equivalent to the name of the builder of the second pyramid, *Shafra* (Chafra), sunlight, the shining one. He then murdered the wise and faithful regent Aristomenes (who by the way carries *Menes* in his name like so many other Greeks), and had to suppress two insurrections against his tyranny. He hated his Syrian wife Cleopatra (the first), and courted the Romans, and was finally poisoned by his ministers.

Ptolemy IV, *Philometor*, again revives in his name the *Meri* of the monuments; but this time the source (or object?) of affection is not the father, but his mother Cleopatra, who ruled as regent from his 6th to his 14th year, and therefore whom he hated cordially. During his captivity in Syria, the Egyptians placed on the throne his brother—

Ptolemy VI, Euergetes II, called Kakergetes, evil doer, by the Alexandrians, and Physcon, from an umbilical hernia; who after various adventures ruled in common, with his brother, under the protection of the Romans. Ebers has laid the scene of his story of the Two Sisters in this double reign.

on this supposition it would become necessary to consider Hephzibah as an Israelitish woman married at the court of Jerusalem.

Manasseh is spelled in Hebrew with four letters, מנשה, MNSE. But whether this be the mode in which it was spelled by the scribes of Hezekiah's court when his son was born, in 705 B. C., is as uncertain as whether the Masoretic pronunciation of the name in the third century after Christ approaches at all the sound of the name as uttered by King Hezekiah's courtiers. All we can go by is the Greek form *Μανασσῆς*, into which it was cast by the LXX at Alexandria or Heliopolis in the third or fourth century before Christ.

Jewish colonies were established in Egypt in the old age of the prophet Jeremiah, about 550 B. C. The traditional pronunciation of Manasseh's name was then only a century or so old; two centuries more could not have essentially altered it. If the Hebrew spelling, MNSE, were capable of a Shemitic explanation, which it is not, we might suppose the *Manasses* of the LXX to be a modification of it under Egyptian literary influence. But it is quite as allowable to suppose that the A in MN[A]SE, or the A and S in MN[AS]SE, preserved by the Jewish scribes at Alexandria, were lost by the scribes at Tiberias or Babylon.*

The etymology of *Manasseh*, son of Joseph "who makes forget" from *Nasha* to forget, is absurd. It is given in Gen. 41 : 51 thus: "And Joseph

Ruling alone he married his sister (who had been his brother's wife also), and murdered her son in her arms on their wedding day. Afterwards he divorced her and married another Cleopatra, her daughter by his brother. His cruelties drove the Alexandrians into all other countries, whither they carried the arts, learning and religion of Egypt. He afterwards murdered his own son; was banished; restored; reigned long; was a great patron of letters, and called by some the Philologist.

Ptolemy VIII, Soter II, was immediately expelled by his mother and became king of Cyprus. Afterwards restored, but not acknowledged in the Thebaid, he reduced the great city of Thebes after a siege of three years to its present ruined condition. He was called *Lathyrus*, "a vetch," from a wart on his nose.

Alexander Ptolemy I, murdered his mother and was assassinated.

Alexander Ptolemy II was also assassinated.

Alexander Ptolemy III was banished, and died at Tyre, leaving his kingdom to the Romans.

Ptolemy XII, *Auletes*, the flute player, received the names: *Philopator*, *Philadelphus*, *Neodionysus* (Osiris, the new Bacchus). He murdered 100 Alexandrine nobles, fled to Rome, lay concealed at Ephesus, and was restored to power by Gabinius, murdered his daughter Berenice, and died leaving orders that his eldest son and eldest daughter should marry and reign together, Pompey being their guardian. His queen was the last celebrated Cleopatra.

*Supposing the (Egyptian MN ASSA) name to be presented for writing to a Jew scribe, he would have spelled it MNSA—MaNaS-A, and considered the duplication of the S unusual and unnecessary.

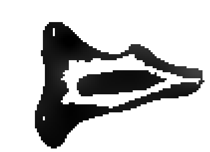
The fact that *Manasseh* (son of Joseph) is spelt in Hebrew (Gen. 41 : 51) MNSE like *Manasseh* (the tribal name, Josh. 13 . 29; 17 : 8) is of no moment, because wherever the name was found, its spellings would be made to agree. That it suffered changes in the course of centuries is rendered probable by the form MNSI in Deut. 4 : 43, "And Golan of Bashan of the Manassites," בבשן למנשי "in Bashan to Minashi."

ERYOPS MEGACEPHALUS. Fig. 1, $\frac{1}{5}$ nat. size. Figs. 9–10, $\frac{4}{15}$.

a—b CRICOTUS sp. $\frac{1}{1}$.

2 ERYOPS MEGACEPHALUS. $\frac{1}{3}$.

PLATE III.



5

6

ERYOPS MEGACEPHALUS. $\frac{1}{4}$.

on this supposition it would become necessary to consider Hephzibah as an Israelitish woman married at the court of Jerusalem.

Manassah is spelled in Hebrew with four letters, מנשה, MNSE. But whether this be the mode in which it was spelled by the scribes of Hezekiah's court when his son was born, in 705 B. C., is as uncertain as whether the Masoretic pronunciation of the name in the third century after Christ approaches at all the sound of the name as uttered by King Hezekiah's courtiers. All we can go by is the Greek form *Μανασσῆς*, into which it was cast by the LXX at Alexandria or Heliopolis in the third or fourth century before Christ.

Jewish colonies were established in Egypt in the old age of the prophet Jeremiah, about 550 B. C. The traditional pronunciation of Manasseh's name was then only a century or so old; two centuries more could not have essentially altered it. If the Hebrew spelling, MNSE, were capable of a Shemitic explanation, which it is not, we might suppose the *Manassēs* of the LXX to be a modification of it under Egyptian literary influence. But it is quite as allowable to suppose that the A in MN[A]SE, or the A and S in MN[AS]SE, preserved by the Jewish scribes at Alexandria, were lost by the scribes at Tiberias or Babylon.*

The etymology of *Manasseh*, son of Joseph "who makes forget" from *Nasha* to forget, is absurd. It is given in Gen. 41 : 51 thus: "And Joseph

Ruling alone he married his sister (who had been his brother's wife also), and murdered her son in her arms on their wedding day. Afterwards he divorced her and married another Cleopatra, her daughter by his brother. His cruelties drove the Alexandrians into all other countries, whither they carried the arts, learning and religion of Egypt. He afterwards murdered his own son; was banished; restored; reigned long; was a great patron of letters, and called by some the Philologist.

Ptolemy VIII, Soter II, was immediately expelled by his mother and became king of Cyprus. Afterwards restored, but not acknowledged in the Thebaid, he reduced the great city of Thebes after a siege of three years to its present ruined condition. He was called *Lathyrus*, "a vetch," from a wart on his nose.

Alexander Ptolemy I, murdered his mother and was assassinated.

Alexander Ptolemy II was also assassinated.

Alexander Ptolemy III was banished, and died at Tyre, leaving his kingdom to the Romans.

Ptolemy XII, *Auletes*, the flute player, received the names: *Philopator*, *Philadelphus*, *Neodionysus* (Osiris, the new Bacchus). He murdered 100 Alexandrine nobles, fled to Rome, lay concealed at Ephesus, and was restored to power by Gabinius, murdered his daughter Berenice, and died leaving orders that his eldest son and eldest daughter should marry and reign together, Pompey being their guardian. His queen was the last celebrated Cleopatra.

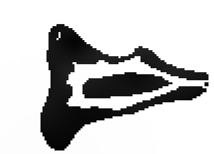
*Supposing the (Egyptian MN-ASSA) name to be presented for writing to a Jew scribe, he would have spelled it MNSA=MaNaS-A, and considered the duplication of the S unusual and unnecessary.

The fact that *Manasseh* (son of Joseph) is spelt in Hebrew (Gen. 41 : 51) MNSE like *Manasseh* (the tribal name, Josh. 13 : 29; 17 : 8) is of no moment, because wherever the name was found, its spellings would be made to agree. That it suffered changes in the course of centuries is rendered probable by the form MNSI in Deut. 4 : 43, "And Golan of Bashan of the Manassites," בבשן למנשי "in Bashan to Minash-i."

ERYOPS MEGACEPHALUS. Fig. 1, $\frac{1}{5}$ nat. size. Figs. 9–10, $\frac{4}{15}$.

a–b CRICOTUS sp. $\frac{1}{2}$.

2 ERYOPS MEGACEPHALUS. $\frac{1}{6}$.



5

6

ERYOPS MEGACEPHALUS. ½.

Proc. Amer. Philos. Soc., Vol. XIX, p. 56.

PLATE IV

ERYOPS MEGACEPHALUS. $\frac{4}{15}$.

21

EMPEDIAS MOLARIS. ½.

Proc. Amer. Philos. Soc., Vol. XIX, p. 56.

PLATE VI.

22–27 DIMETRODON INCISIVUS, $\frac{1}{4}$, except 8 and 9, = $\frac{3}{4}$.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIX. JUNE TO DECEMBER, 1881. No. 109.

TABLE OF CONTENTS.

called the name of his first born Manasseh; for God hath made me forget all my toil and all my father's house. And the name of the second called he Ephraim: for God hath caused me to be fruitful in the land of my affliction." The Hebrew Scriptures are full of such punning etymologies of later times when true meanings of the old names had been lost, and new meanings had to be invented and corroborated by fictitious anecdotes.*

The fiction is particularly unfortunate in this instance, since the legendary name of Joseph's wife and Manassah's mother is Asenath, AS-NUT "image of the goddess Naut," a perfectly well known Egyptian compound. And the legendary name of her child *Manassa*, "Image of Menes, agrees strictly with her own." One of the elements in the compound being the same in both names; and the demigod first Pharaoh Menes being substituted in the name of the boy, for the divine Neith in the name of the mother.

The name of the founder of Egypt is written MNA, and the etymology claimed for it is got from the verb *man* or *men* in its meaning of *stability*, preserved in the Latin *manere*, to remain. The word AS is used monumentally for *throne* and *statue*, and for *prince*. Both throne and statue represent royalty. *Man-Assa* would then mean "firmly established royal power."

Whether this was really the sense ascribed to the name, or whether it was understood in some other sense less abstract, matters not. The only point I wish to illustrate is the pure Egyptian quality of the name of this King of Judah, so closely allied both in his politics and in his religion, with the Egypt of his day. His alliance however availed him little. Egypt was always a broken reed to lean on. Esarhaddon came and Manassah was carried away captive to Babylon, where he probably perished;† although the priestly tradition is that he repented, was restored to his throne, and became a pious Jahvist, dying in peace at the

* The language of the hieroglyphics was gradually made a "benefit of clergy" in Egypt itself; and it is more than doubtful whether Herodotus was permitted to get the least insight into it. Diodorus shows clearly that in his day, first century B. C., it was a sealed book to the most curious of the Greeks. One of the most striking examples of this ignorance in which even common Egyptians were kept, is adduced by Krall (in his Manetho und Diodor, Sitz. d. K. AK. d. Wiss. 1880, p. 215). Herodotus found on the roads from Ephesus to Phocæa, and from Sardes to Smyrna, Egyptian monuments which local tradition called images of Memnon, made by Sesostris, on one of which was an inscription in hieroglyphics passing from one shoulder to the other. He gives the following absurd interpretation of it, 'εγὼ τὴν δὲ την χώραν ὤμοισι τοῖς ἐμοῖσι εκτησάμεν, "I have won the country with my shoulders (arms)," as quite reliable. Knowing nothing of the language, he had the inscription interpreted for him by one of the Egyptian colonists at Larissa (a city not far to the south-east, founded by the Egytian confederates in the army of Crœsus), who, although an Egyptian, knew as little about the hieroglyphic language as Herodotus himself did.

† In 2 Kings 21 : 18, nothing is said about his repentance, but he is buried in his garden Uzza.

age of 68 (664 B. C.); having reigned 60 years, a longer reign than that of any other Hebrew monarch.

"*Amon* his son reigned in his stead."

Nothing more can be asked in demonstration of the Egyptian name of the royal father; the royal son bore the most sacred of all the divine names of the Egyptian Pantheon, AMN, Ammon Ra. Consequently he "walked in all his father's ways and served the idols his father served, and worshiped them; forsaking Jehovah, god of his fathers, and walking not in Jehovah's ways,"—but only for two years; for at the age of 24 his servants slew him; and the populace slew the conspirators and placed Josiah on the throne.

Josiah, the 8 year old son of the murdered Amon, was a pious boy, and a staunch Jahvist King, no doubt through the influence of his mother, Jedidah, daughter of Adaiah of Boscath. Her name ידידה, *Ididê*, "the beloved one," curiously resembles in spirit that of Manassah's mother, *Hephzibah*.

Its resemblance to the pet name of the little Solomon, ידידיה, *Ididiê*, "the beloved of Jah," is equally remarkable, especially in view of the likeness which this last bears to such Egyptian names as *Meri-n-Ra*, *Meri-n-Amun*, *Meri-n-Ptah*, &c.

The difference between *Ididê* and *Ididiê*, may indeed not have been an actual one; or, may have resulted from the difference of sex. It is, however, very noteworthy that the heathen *Amon's* wife's name does not seem to have included the Jahvist element, any more than did Hephzibah; and therefore, we are left to conjecture that it was bestowed upon her by her loving spouse.

The name of their son *Josiah*, LXX 'Ιωσίας, יאשיהו, *Jas'ieu*, "whom Jah healed," if this be its correct etymology (from יאש healed), refers directly to Jehovah; and the wonder is that Amon should have given such a name to his child. It is quite possible, however, that the boy was saved from some serious infantile disease by a priest-physician of the native religion, and that the infidel father was superstitious enough to give the national deity the credit of the cure.

On the other hand, great obscurity hangs over the true etymology of proper names ending in U.* And if the Mosoretic pronunciation *Joshiahu* be accepted, another very disturbing Egyptian element enters the name.

*Some of the Egyptian names ending in U seem to have been considered (at least by the scribes of the XVIII XIX Dynasties) as plurals, because they repeated the previous letter three times, or followed it by three strokes (both signs of plural); as in the case of Ra-aa-χeper(u) 71st on the Tablet Abydos; Ra-men-χeper(u) 72nd; Hor-men-Ka(u) 31st; Ra-...Ka(u) 53rd: Ra-neferKa(u) 54th; Hor· nefer·Ka(u) 54th; Ra-nub-Ka(u) 61st: Ra-sha-Ka(u) 63rd.

But in Ra-nefer-Ka-shu-tu, 45th; Ra-nefer-Ka-n-nu, 52nd; Ra-ma-ma-χer-u, 65th (a very remarkable name, involving the symbols of justification, from which, as I have elsewhere shown, the Greeks got their μαχαρῖος, blessed) the final U is a distinct literal element of the name, or seems to be.

It is true the *h* here is the weak ה and not the strong ח; but that is as open to conjecture as all the rest. If it were written יאשְׁחוּ then we have a genitive followed by *aχυ*, as in the case of the name of the Sphinx Hor-m-aχu. Or χυ alone, would suggest the name of the Euhemerist Pharaoh χυ-n-aten. And the number of names in Egyptian and Hebrew as well as in Sanscrit ending in U, is very remarkable, and deserves a special investigation. It is noteworthy that the LXX *'ιωσία-ς* does not express the final *u;* as if the name as known to them was simply *Jas'-Ja'*. "Jehovah heals." Again there seems no good reason for the transposition of the elements of *Josiah* when compared with *Joshua*, which is written with the יהו not *after* but *before* the verb, and yet is translated in exactly the same way by the etymologists "whom Jehovah saves."

The fact seems to be that 1. We are quite ignorant of the genuine original forms of such proper names; 2. We are equally ignorant of the correct meaning of their elements, even such as they have come to us by tradition; and 3. No sound canon of grammatical interdependence of the elements has been established; and that because exegetical etymologists have been content to study the names embodied in the literature of one people quite apart from the names embodied in the literatures of other nations.

It is very doubtful if the name of the hebrew deity, Jehovah, is at all represented in a multitude of proper names in the Old Testament for the interpretation of which it has been taken for granted, merely on the ground that they were or are supposed to have been hebrew names.

Josiah is a flagrant instance of this uncertainty.

The hebrew history of this monarch's reign is of the highest importance to the student of that chronic war which raged in Palestine between the Jehovah cultus and various other religious rites. His open, powerful and persistent efforts to fix the national mind on one god, Jehovah, is described as commencing in his 20th year (the 12th of his reign). The chronicler says, that when he was only 16 years old, "while he was yet young, he began to seek after the god of his fathers." This would imply that before that he had been an idolater, like those around him. The older historian says nothing of this, and nothing even of the terrible raid which, in his 20th year, the chronicler reports him as making upon the high places of Judah and Israel. The older historian passes over all this and commences his account with what Josiah did in his 26th year (18th of his reign). Both accounts then agree in telling, almost in the same words, how he sent Shaphan, the scribe, to Hilkiah, the priest, to take account of the temple money offerings, and to apply them to the restoration of the dilapidated edifice.

Hilkiah told Shaphan that "he had found the book of the law in the house of Jehovah." Shaphan read it; and read it to Josiah, who rent his clothes in dismay at its contents, and ordered Hilkiah, Ahikam, Achbor and Shaphan to consult the oracle, "to inquire of Jehovah, for

him and the people and all Judah, concerning the words of the book: "for great is the wrath of Jehovah kindled against us; because *our fathers* have not hearkened unto the words of this book, to do according to all that is written concerning us."

Huldah, the prophetess, was the pythoness of whom they sought the oracle. There is no mention of any oracle in the temple itself. There seems to have been no Shekinah; no high priest privileged to ask of Jehovah himself.

Huldah is thus described: "Huldah, the prophetess, wife of Shallum-ben-Tikvah-ben-Harhas,* Keeper of the Wardrobe. She dwelt *in the college* in Jerusalem." 2 K. 22: 14. This is evidently an explanatory gloss of later date.

Huldah's prophecy of peace to the King, and disaster to the Kingdom, then causes a convocation; a solemn covenant between King, people and Jehovah; a complete cleansing of Jerusalem and of the whole land; the utter destruction of all idols, and abolition of strange rites. The story is very elaborate, and fully proves the prevalence of every variety of foreign cultus previously, and the virtual invention of the Passover as a national festival at this time. And it looks as if the whole history of the Exodus were invented on this occasion for the purpose of erecting an impregnable barrier against Egyptian influence and ideas.

However this may be, the Egyptian alliance was so completely broken up, that when the Pharaoh Necho took the field against Assyria, Josiah intercepted his march at Megiddo in the north, and was defeated and slain, in spite of his pious zeal for Jehovah. It was no doubt to explain this astounding calamity, that the story of Huldah was invented and introduced into the annals of the reign, by subsequent historians.

Jehoahaz, Josiah's son, bore the name of a much more ancient King of Israel, son of Jehu.—It is remarkable that *Jehoahaz* is said to have had another name, *Shallum*, שׁלם, "*retribution*," which was the name of the 15th King of Israel, who slew Zechariah, son of Jeroboam II, and thus extinguished the family of Jehu. It seems perfectly inexplicable that the fanatical Jahvist Josiah should have given not merely one but two accursed names to his son and heir; and that one of these names should have suggested the murder of the man's race who bore the other.—And another remarkable thing is that *Shallum* was also the name of the husband of Huldah the prophetess.—Either such names are merely the inventions of subsequent chroniclers; or, they are mixed up in the history so as to divest them of all personal genuineness; or, they were bestowed without regard to their meanings; or, lastly, their reputed meanings are good for nothing.

Jehoahaz was 23 years old, and only reigned three months after the defeat and death of his father. He is said to have spent these three

*The uncertainty surrounding hebrew private names is exhibited here; for the chronicler (2 Chron. xxxiv, 22) repeats the story almost verbatim, and yet gives this name Harhas חרחס, as Hasrah, חסרה, a totally irreconcilable difference, not to be explained by any ordinary blunder of transcription.

months in upsetting his father's Jahvism, and restoring idolatry. Necho, on his arrival at Jerusalem, sent him a prisoner to Riblah in northern Syria, and made Josiah's brother, *Eliakim*, King, turning his name to *Jehoiakim*.

Eliakim, אליקים, ALIQIM, is supposed to mean "God has appointed him" (Ges.) from קום, to rise, stand; קים, piel, to make rise, stand, confirm, establish &c. If this be so, then why does Gesenius say of אליקא (2 Sam, 23 : 25) "etymology unknown," when it should mean "God has spewed him out," from קוא, to spew out? What is good etymology in the one case should be good in the other.—But a more embarrassing question arises :

Jehoakim (Eliakim) should then mean "Jehovah has appointed him." Now, how is it possible to suggest any motive for an Egyptian King changing his Hebrew vassal's name by substituting "Jehovah" for "El;" especially seeing that he himself worshiped *El* (=RA), and his vassal (so the history goes on to state) hated Jehovah, "as all his fathers had done?"

This again shows that either the hebrew traditional names are wrong, or that their hebrew traditional etymologies are valueless.

It must be noted that Josiah's mother was *Jedidah;* but his brother Jehoakim's mother was *Zebudah;* so they were only half-brothers; and while Josiah was 39 years old, his half-brother, Jehoiakim, was only 25. These 14 years may have made a great change in the hareem of King Amon, and goes far to explain the anti-Jahvism of the younger half-brother.

Undoubtedly polygamy at the court of Judah was the ground cause of the continual revival of anti-Jahvist worships in the history of the kingdom. Josiah's own children could have very little chance for a good education in their father's orthodoxy, surrounded as their infancy and adolescence must have been by female worshipers (open or secret) of Baal, Moloch, Chemosh, Rimmon, Thammuz, Astarte, Neith, and other Syrian and Egyptian deities. It is only surprising that the titles of these deities do not appear in the lists of royal names. Why do they not? Were the mothers deterred from naming their children after the deities which they were permitted openly to adore? That is evidently no explanation. Are we then left to conjecture that the reiterated story of this court idolatry is in the main a mere late priestly tradition, without foundation in fact, and penned for a long subsequent purpose, viz., to account for facts otherwise unaccountable?

Among other nations, Greek, Phœnician, Assyrian, Babylonian, Egyptian, the national pantheon is painted and recorded in each royal nomenclature. The Hebrew annals, both Kings and Chronicles, have this exceptional feature : they affirm that kings and people alike were habitual worshipers of numerous well-known deities, and yet, while they record lists of royal and common names compounded from the name of one

asserted national deity, they record none compounded of the names of the deities said to have been habitually worshiped; except the three or four mentioned in previous portions of this paper.

It seems to me that this fact has been overlooked, and ought to be taken into account in judging 1. of the trustworthiness of the hebrew chronicles, and 2. of the correctness of the exegetical etymologies in our hebrew lexicons.

If it be sound historical argument that the Pharaohs of the III and IV Dynasties were pious worshipers of AMUN-RA, the national deity, because they were named *Ra-neferka, Ra-fu,* * *Ra-tatef, Ra-Shaf, Ra-menkau,*—and if it be a fair inference that *Asdru-bal, Hanni-bal, Ha-milcar* and other Phœnicians were honest and consistent worshipers of *Baal-melcarth,* the phœnician deity,—it seems an equally reasonable conclusion that if the Judæan and Ephraimitish princes had names in which the word Jah or Jehovah can be recognized, they must have been worshipers of Jah, although the chronicles vehemently affirm that they were not.

In other words, historical analogy would teach that the Kings *Abi-jah, Jo-saphat, Jo-ram, Jeh-u* (? Jah-u), *Hezek-jah,* &c., were all alike worshipers of Jah, with Jah's prophets *Sephon-jah, Eli-jah, Jo-el, Isa-jah,* &c., and in spite of the historical denunciation of their alleged idolatries made by the compilers of the Kings and Chronicles of after centuries. If not—then we are compelled to assume that the deity name, Jah, is wrongly identified in their proper names.

It is certainly a remarkable thing that the kings who are traditionally reported as founders of the Jehovah worship, Samuel, Saul, David and Solomon, do *not* carry the name of the deity in their names.

And the same argument may be reasonably employed in investigating the antiquity of the Jehovah worship, in view of the startling fact that none of the patriarchal names exhibit this element: neither Heber, nor Terah, nor Abram, nor Sarah, nor Ishmael, nor Isaak, nor Rebekah, nor Esau, nor Jacob (Israel), nor a single one of their numerous reputed offspring, Reuben, Simeon, Levi, Judah, Zabulon, Issachar, Dan, Gad, Asher, Naphtali, Joseph, Benjamin, Eliphaz, Reuel, *Jeush,*† *Jaalam,*†† and Korah. It is needless to say that none of the "dukes of Edom" (Esau's children), Teman, Omar, Zepho, &c. (Gen. xxvi: 15), contain Jah. But it is worthy of deep consideration that Jacob's descendants do not seem to have been called after the "Lord God of their fathers."

Judah's sons were called Er, Onan, Shelah.

In the next generations come: Pharez, Zerah, Hezron, Hamul, Zimri, Ethan, Heman, Calcol, Dara, Achar, *Azariah* (son of Ethan, 1 Chron. ii: 8), Jerameel, Ram, Chelubai, Amminadab, Nashon ("prince of the Beni-Judah" 1 Chron. ii: 11), Salma, Boaz, Obed, Jesse, and his seven sons,

* Supposing that the barred disc of the tablets, *Shu*, is a mistake for the plain disc, *ra*.

† יעיש JOIS. †† יעלם JOLM. But these names commence exactly alike, but have received from the Masorites different punctuation, for no apparent reason. Neither of them show any trace of Jah.

Eliab, Abinadab, Shimma, Nethaneel, Raddi, Ozem, David, with their two sisters *Zeruiah* and Abigail.

Of all these names, Azarjah and Zerujah alone contain the Jah (and the very late date of the list makes these suspicious), yet this is the royal line of David, "the man after Jah's own heart," the supposed designer of the temple, and the supposed inventor and establisher of the liturgy of Jah.

It may be said that the negative argument is of no weight because it proves too much; for neither does this long list of names exhibit the title of any other deity. In reply it may be said:

1. That the absence of other deity names is not certain until the personal names are investigated in light of the comparative mythology of that day; and

2. That several of them do contain the name of the Assyrian and Egyptian deity Bel, El (=Ra :) viz. Ishma*el*, Isra*el*, Reu*el*, Hamul (?), Calcol (?) Jerame*ël*, *El*iab and Nathane*ël*.

Of Hezron's descendants in the line Caleb: Jesher, Shobab, Ardon, Huz, Uri, *Bezeleel;* in the line of Segub, Jair, Ashur, Tekoa; in the line of Jeremeel, Ram [Bunah, Oren, Ozem, *Ahijah,*] Onam [Maaz, Jamin (c-Benjamin), Eker,] Shammai, [Jada,] Nadab, [Abishur, Ahban, Molid, Seled,] Appaim, Ishi, Shéshan, [Ahlai, Jether, Jonathan, Peleth, Zaza,] Attai, Nathan, Zabad, Ephial, Obed, Jehu, *Azariah*, Helez, *Eleasah*, Sisamai, Shallum, Jekamiah, Elishama, extending through 21 generations =600 years, *i. e.* down to the captivity of the ten tribes—only two have the word Jah, and both are comparatively late, *Abijah* and *Azariah*.

A valuable bit of information for our purpose is given in the following words (1 Chron. ii, 34) "Now Sheshan had no sons, but daughters. And *Sheshan* had an Egyptian slave, his name *Jarha*. And Sheshan gave his daughter to his slave Jarha to wife; and she bare him *Attai*. And Attai begat Nathan;" &c., as above.

Here, if any where, we might find pure Egyptian names; שֵׁשָׁן S'é-S'a-N, יַרְחָע IRHO, עַתַּי OTI.

A most remarkable coincidence in fact occurs. This Sheshan father of Attai corresponds so closely and unexpectedly with the *Shesh* and *Atta* of early Egyptian story, that the reference of one to the other in some unexplained and perhaps inexplicable way seems inevitable. The Egyptian part of the coincidence is referred to in a recent memoir by Dr. Jacob Krall* "On the composition and fate of Manetho's History;" where, after recounting the evidence of the mythical character of the lists of names of the Kings of the 1st, 2d and 3d dynasties, preceding the 1st King of the Karnak tablet (probably the first really historical King) Snefru (1st of the 4th dynasty of pyramid builders) he goes on to say:—

"We are moreover in a condition to suggest the origin of these mythical accounts. A series of chapters (of the Ritual) and especially powerful formulæ were relegated by the priests to the days of their most ancient Kings. Chapter 130, e. g., to the reign of Husapti (υσαφειδης) I. Dy. 5th

*Sitzungsberichte der K. AK. der Wiss. Phil. Hist. Cl. XCB, Juli 1879, p. 130.

King ; Chapter 64, to the reign of Menkaura (builder of the third pyramid).*

"We read, again, in the Medical Papyrus Ebers of a hair salve prepared as long back as by *Shesh* the mother of *Teta,* (TTA) apparently the *Αϑωτις* of the lists, 2d King of the 1st Dynasty," the immediate successor of Menes, &c.

The tablets of Abydos and Saqqara give the following combined list of names of the Kings of the first three dynasties : Mena (Menes), TeTA, ATeTh, ATA, Kenkenes, Husapti (Sapti), Meribapu, Semempses, Qebuhu, Butaŭ, Qaqeu, Ba-n-neter, Watnas, Senda, Hetefa, TTAA (T'atai), Neferqara, Sokarneferka, Nubkara, Sar, Sar-TeTA, Huni. Snefru.

It will be seen that TTA occurs with slight variations five times in this list of 23 Kings. The hair-ointment is assigned to the mother (*Shesh*) of the first one. I give little weight to Krall's etymologies of these names, although he accepts them as "ganz abschliessend festgestellt" by Lauth, in his Manetho (p. 87). I prefer to refer them all (as mere modifications) to Tat, the sacred symbol, Nilometer, or what not, used incessantly in the priestly literature and on the monuments with numerous meanings more or less radically different. But I wish to insist here on the striking fact, that the value of this famous verb and known root of Egyptian literature could not very well be more highly guaranteed and illustrated than by its being used alone and without any other compounding element to manufacture (whether historically or traditionally or mythically is a question of no moment here) the personal names of *five* out of 23 of the most ancient Kings.

Its value is further shown by the fact that it entered as a compound into the names of many other Kings (like Ra·tat·f, Tat·kara, &c.) of succeeding dynasties.

Its highest value is exhibited in the name of the special god of the clerici, clergy, clerks, scribes, the god of learning, *i. e.* worship, *Thoth.*

But it appears among the names of the egyptian nobility or bourgeoisie (for it is hard to distinguish between these classes, distinct as they become in modern times) ; as, *e. x.*—In the tombstone of a gentleman of the Ancient Empire preserved in the Boulaq Museum at Cairo (No. 71, Magazine V, Mariette's Aperçu.), the legend runs, that his name was, ATA ; his father's ....*ua* ; his mother's *Neb·t* ; and his son's *Sebek-nefer.*

Taking this private name (in the 5th dynasty ?) ATA, and comparing it with the royal names ATA, ATeT, TeTA, and TeTAi of the 1st and 2d dynasties, we can not be surprised at the appearance of the name ATI, in 1 Chronicles ii: 34, *given, as it is there, to the son of an Egyptian,* the slave of one of the descendants of Judah. But the marvel is that the slave's wife's father should have the egyptian sounding name *Sheshan ;* and that the Ebers Papyrus should call the mother of the pharaoh TTA, *Shesh!*

To return to the list of early names in 1 Chron. ii : 17.

*4th King of IV Dy. if Snefru were the 1st. But if Snefru was the last King of the III D then Mycerinos was 3d King of the IV D.

Although one of Jesse's nine children (notably one of his two *daughters*, and not one of his seven sons) *Zeruiah*, seems to carry the *Jah*, it is remarkable that it does not appear in the names of her three sons, *Abishai*, *Joab* and *Asahel*, אבשי, יואב, עשה. (ABSI, IUAB, OSEAL) in the first and second of which *ab*, father, is the main element,* the *si* (shi?) of the one and the *iu* of the other, being of unknown sense ; for *iu* =Jah, (Jahveh) there is no evidence whatever.

The third name, *Asahel*, is given in our modern hebrew text as a compound name, with a hyphen between the OSE and the AL, evidently inserted to support a popular or Masoretic etymology עשה־אל, "God made," *i. e.* him ; or "God works" in the indefinite or abstract sense.†

The other sister of David, Abigail, married Jether the Ishmaelite, and bore *Amasa*, whose name has a pure Egyptian ring ; and, considering the relations of the desert to the delta, we should expect to find plenty of Egyptian elements in Ishmaelite nomenclature. Amasa is written OMSA, which might easily be the Judæan pronunciation of *am-se*, "(his) mother's son ;" but a vague conjectural suggestion like this, however poetical and even proper to the circumstances, can be of no scientific value.

The grand fact stands out visibly, that in the family circle of David, the man after Jehovah's own heart and the supposed instituter of Jahvism, there is but the one trace of the existence of a Jehovah worship, viz., in the name of one of his sisters, Zeruiah, צרויה, and that is doubtful for good reasons.

That there were two philological elements in Judæa is curiously illustrated by the fact that the unfortunate son of Saul and rival of David is named in one document (1 Sam. xiv: 49), ISUI, ישוי (Ishui) ; and in another document (2 Sam. ii : 8) a translation of *isui* is made into AIS-BST איש־בשת (Ish-bosheth) "man of folly." *Ishui* was his Ephraimite or Hebrew name, and *Ishbosheth* was the nickname given to him in the camp and at the court of the men of Judah. Had it occured first in Chronicles, we would be compelled to consider it a priestly term of reproach of the times of Ezra.

Jedidah was a similar nickname given to *Solomon* at his birth by Nathan the prophet, but from an opposite (Jahvist) stand point. It occurs in one of the older and more reliable documents, 2 Sam. xii : 25, and is probably one of the earliest genuine instances of the actual establishment of the Jehovah cultus, and goes far towards removing our doubts of its existence in the times of David. ידידיה (IDIDIE,) can hardly mean anything else than "Jehovah's darling ;" (compare *Jedidah* "Her beloved," the proper name of the mother of King Josiah ; 2 Kings, xxii : 1, and *Jedideka*, "thy beloved ones" in Ps. 127: 2. There is but one suspicious circumstance, viz., that it is a pretty fair pun upon the name of the baby's father, *David*, דוד (DUD) or as it is written also דויד (DUID) Hosea iii : 5.

* Unless the Egyptian *ab*, libating priest be preferred; as in the name Ka-ab of χufu's son, (6, D. § 151, 155 MS.)

† Another עשׂה is given by Gesenius as an absolute root meaning "to be hairy, rough, shaggy." c. Arabic. Hence proper name *Esau*. But the probability is that the whole story of Esau's hairiness was worked out of this late etymology, itself entirely worthless.

This name, *David*, first appears in 1 Sam. xvi, 18, in Jewish history, where it is written DUD, as is usual in the earlier documents, gradually changed to DUID as time went on. Its early form is important, because it is identical with the Hebrew word דוד, DUD, a *pot, kettle, basket* (Job, 1 Samuel, 2 Kings, Jeremiah, Psalms, 2 Chronicles) from the connection of which with *boiling over fire*, came a verbal DUD, *to boil, to be agitated, to love;* the plural noun DaDIM, *sexual love* (loves); the singular noun, *a love, a friend, an acquaintance;* and the title, DUDE, *aunt*, father's sister or uncle's wife. Hence DUDI (*my delight*, Roy), the mandragora or love apple, Gen : xxx, 14, Cant. vii : 14, and DUDU (*his beloved?*) a proper name (Roy).

AEB is the regular hebrew verb *to love;* χMD means to love covetously; χNN, to love with compassion; χSD (עסד), to love with benevolence, to be gracious; χPZ, to love with joy and delight; χ'SQ, to love with esteem, as a companion; IDD, simply TO LOVE, to be pleased with, *i. e.*, without sexual emotion; IDO, to love with reverence based on knowledge (a mere poetical use); IRO, to love with worship (ditto); OGB, to love lewdly; RχM, to love as God loves and pities men; S'CB, to lie with.

David's children's names are given in an old document, 2 Sam. v : 14, and in a much later one, 1 Chron. iii : 1, thus :

1. Born in Hebron :—1 Chron. iii : 1.

Amnon,	אמנן	of Ahinoam of Jezreel.
Daniel,	דניאל	of Abigail of Carmel.
Absalom,	אבשלום	of Maachah, princess of Gesher.
Adoni-jah,	אדניה	of Haggith.
Shephat-iah,	שפטיה	of Abital.
Ithream,	יתרעם	of Eglah, "his wife."

2. Born in Jerusalem :—

2 Sam. v : 15.		1 Chron. iii : 5.	
Shamuah,	שמוע = שמעא	Shimeah,	Of Bathshuah (Bathshebah) "four."
Shobab,	שובב	Shobab,	
Nathan,	נרן	Nathan,	
Solomon,	שלמה	Solomon,	
Ibhar,	יבחר	Ibhar.	
Elishua,	אלישוע=אלישמע	Elishama.	
	אליפלט	Eliphelet.	
	נגה	Nogah.	
Nepheg,	נפג	Nepheg.	
Japhia,	יפיע	Japhia.	
Elishama,	אלישמע	Elishama,	
Eliada,	אלידע	Eliada.	
Eliphalet,	אליפלט	Eliphelet, "nine."	
	תמר	Tamar, "their sister."	

"Besides the sons of his concubines."

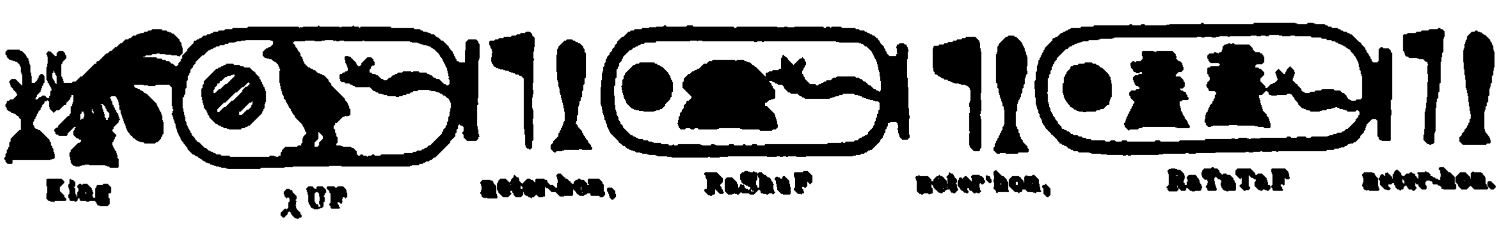
It is evident that the second list in Chronicles is a bad copy of the list in 9 Samuel, or of some document the source of both lists, from the blunder of the scribe in *repeating Elishama** and *Eliphalet*. Where the chronicler got his *Nogah* can only be conjectured from its distant resemblance to the following name *Nepheg*.

How many other errors of transcription there may be in both lists no one can now find out. But it is evident the *Jah* does not occur in any one of the names of the eleven children of the reputed founder of the *Jah cultus*, said to have been born to him in Jerusalem, where he is supposed to have prepared the site of the *Jah temple*, its erection being only prevented by the superior influence of the *Jah high prophet* Nathan, whose name one of his children in the Jerusalem list bore. The meaning of this obstruction has been much debated. Shiloh in Ephraim had an ancient prescriptive right to the Egyptian *Ark of the Exodus;* and *Nathan*, its then president prophet, foresaw the rupture which actually ensued when the Ark which belonged to the *Beni Israel* was taken to glorify the *Anshi-Judah*, and the provincial Baal-Apis worship of the north was swallowed up in the metropolitan Jah worship of the south.

Nathan, נתן, "he gives," "he gave," is the orthodox etymology of the name both of David's son and of his tutor, the old prophet of the ark at Shiloh.

I propose a very different and purely Egyptian etymology :—*Neter-hon*, the commonest of all the titles on the monuments. Its adoption by the prophet of Shiloh would be of unquestionable propriety. The following examples will suffice to explain its use in the hieroglyphic legends :—

On a stele, found in the Serapeum, and now deposited in the Louvre, *Psametik-munχ* calls himself :—"Prophet of Isis, lady of the Pyramid, Osor-hapi, and of Hor-m-aχu the great Sphinx," and then adds the following additional titles to his name :†—



These were the three earliest Pharaohs of the Fourth or Pyramid building dynasty, and to every pyramid there were consecrated sepulchral rites and a resident priesthood, as is the case in all Catholic countries now, priesthoods being invariably attached to churches built over tombs, with shrines for the worship of dead saints, martyrs and royal benefactors of religion. This title *Neter-hon* was in constant use from its earliest appearance 3000 B. C. down to the conquest of Egypt by Alexander, 332 B. C. and later. It was exceedingly common in the time of David and Solomon ;

* This is, however, not a repetition, but a misreading of *Elishua* (מ for ע) in the other list.

† The absence of any genitive form is characteristic. It may be used as an argument for the archaic character of such hebrew names as *Ab-salom*, instead of *Abi-salom*.

and if an Egyptian at Solomon's court were to pay his respects to *Nathan*, he could only do so with propriety by addressing him as the great *Neter-hon* of the Ark of the Covenant of God, and of the shrine at Shiloh. There was no other phrase in the Egyptian language which he could use with equal propriety according to custom.

Neter-hon means *Divine prophet*, the hatchet standing for God, and the second symbol for prophet. Translated into Hebrew it would be *El-shaphat* (shophet). It is not a little remarkable that the fifth name on the list of the six sons said to have been born to David (each of a separate wife) in the old capital of the south, Hebron, is:—

Shephatiah, "the prophet of Jah." But this name is not more significant of *Jahvism* in David's family *at Hebron* than the name of his fourth son

Adonijah, "My lord, Jah;" and it would be folly to attempt to find any foreign etymology for so pure and purely orthodox a Jewish compound word.

Absalom, "father [of ?] peace" is as easily recognized, in its Hebrew dress as Melchizedek "king of righteousness," but—

Daniel, Ammon, Ithream are meaningless; with a suggestion, however, in favor of—

Dani-el, "Judge of [for] God," therefore equivalent to *Shephatiah*. (See Ges.)

Ithream, "He makes abound the people" (Ges. suggests "abundance of the people") like the various Greek names ending in λαος, and δημος:—*Archelaus* (people's ruler), *Aristodemus, Laodamia, Laodice, Menedemus, Menelaus*, &c.

Amnon, "The faithful," seems allied to Amen, *Amnah*, verity, a covenant, *Amnon*, verily. Although the root of this Hebraism is undoubtedly the AMN, "stability," of the early egyptian monuments, there is no need of seeing in this name of the eldest son of David any *direct* reference to its Egyptian source. But it is permissible to notice the curious (if entirely accidental) coincidence, that this first born of the long and splendid lineage of David, the virtual founder of the Jewish monarchy and Jewish religion, happens to bear the very name assigned not only to the greatest of all the gods of Egypt, but also to the first monarch of the first dynasty, MNA; the establisher of monarchy; the head of a splendid procession of rulers, among which one at least gave his daughter to Amnon's brother Solomon to be his queen of queens.

One more word about the Egyptian train of ideas concealed in the Hebraic nomenclature.

In Zechariah vi: 11 to 18 occurs a remarkable reference to Egyptian titles and customs, in a confessedly difficult passage involving the famous name of the second Moses—*Joshua*.

The prophet writes: "Take silver and gold and make crowns, and set them on the head of Joshua the high priest, and say to him: Thus saith Jehovah of hosts: *Behold a man, his name* BRANCH (*Zemach*) under

whom it shall sprout;* this one *builds* (*bana*) the temple of Jehovah. This one *shall build* (*ibneh*) the temple of Jehovah; and this one shall *wear* HOD, and *sit and rule on his throne*."

V'*hua issa hod;* "*and this* (man) *shall wear* הוֹד, *majesty*, splendor, beauty, brightness, (often coupled with HDR, ornament, decoration, splendor, pomp, as in Ps. 45: 4) used of Kings, 1 Chr. xxix: 25, &c., and of a voice Is. 30: 30, Job. 39: 20. Here in Zach. it must mean some regal insignia, a crown, or diadem.

Now this hebrew word HUD corresponds to HT the *white* crown of Upper Egypt, (TSχR being the name of the *red* crown of Lower Egypt,) and to P·S·χN·T the combined crown of Upper and Lower Egypt, (p = the egyptian article; s = the formative, by which nouns are made verbs, see below, and also the causative; t = a final, often not radical, and not certainly radical in this case).

The *double crown* has for its root χN= חן, חד, חוד, in which form it does not appear in hebrew; (for, חד means *one; sharp, to be sharp;* and חוד is to riddle, propose a riddle (Judg. 14: 12); חידה an artifice, a riddle, parable, proverb;) unless in the side meaning חדה to *rejoice;* cognate with חין beauty (Job. 41: 2, spoken of trappings, ornaments).

The *white* crown of Upper Egypt, the crown of the great Middle Empire (XI, XII Dy.) the crown which carried the royal emblem the Uræus, or Cobra, on its front, the crown of Thebes, the Up-country, the Upper World, was called HT, (not χT,) and corresponds to the הד or הוד of Zacharias.

The exact correspondence between the Egyptian and the Hebrew is manifested by the fact that the root *het* (spelled with the globe standard and snake) carries the general meaning of "brilliant, lightening, bright and white." (Brugsch Dict. page 1015.) Sometimes the solar disk with three descending rays is the ideograph; and in one passage (Leps. D. iv, 48, a) *Ra ur s·het χeperu hi ti asep hi ma senen-f,* (with *ra* after the crown and after *asep*) "*the governing sun illuminates* (*s·het-ra*, makes white or bright) *all things, so as to give to exhibition* (bring out to view) *their forms,*" we have an important suggestion of the *causative* force of the *S* in the name of the double crown *p·s·χnt.*—This *het*, followed by nub (gold) means "silver," *i. e.*, white gold, &c.—The Egyptian way of spelling the crown with the standard, t, and the figure of the crown, shows how they meant to intensify the ideas 1, of ornament and 2, of dignity.

The Egyptian simple letter *h* (the fret) in this *het* corresponds to the hebrew ה; but there is one striking analogy which shows that it is transmutable also into ח; for, the Egyptian word *HANA* (followed by a sit-

* Phillippson.—Dewette translates it differently: "who shall sprout up in his place." I think it plain that this sentence is an interpolated gloss, or attempt to explain the meaning of the word Branch *semach;* but it is of no importance here, because the meaning "branch" for semach is accepted, both as verb (Gen. 2: 5, 41: 6) and noun (Gen. 19: 25, &c.).

ting man with his hand to his mouth) meaning *velle*, *placere*, s'il vous plait, s'il est permit, (Brugsch, Dict. p. 903), *i. e.* "by your favour" "by your gracious permission," "may it please your gracious majesty," &c., corresponds exactly to the Hebrew χN (חַן) *grace*, *favor* and חָנָה to *protect*, defend, encamp, surrounded, dwell, reside.

There is therefore no obstacle in the way of comparing the HUD, which Zachariah prophesied that the High priest Joshua should wear as Lord of the new Temple, directly with the HeT, the white crown of Upper Egypt, if not with the *pshent* of the whole Kingdom.*

But this is not the most interesting point in my discussion of the passage in Zecharias, although it bears upon its general Egyptological character. The main point is the use of the word *Zemach*, "branch," and its reference to a late high priest bearing the ancient name Joshua.

The Hebrew tradition, adopted by the Christian Church, saw in the term *Zemach*, Branch, as used by Jer. 23 : 5, 33 : 15 and Zech. 3 : 8 and Thes. 6 : 12, the Messiah, as offspring of David and of God ; while its use by Isaiah 4 : 2 is more doubtful, as Genesius explains.

1. I wish to call attention, first, to the poetic alliteration of the sentence in Zechariah : *Zemach shemo*, "*Branch*," (is) *his name*. How far this alliteration availed in causing the selection of the word, I cannot tell ; but this kind of elegant punning is, as all readers of the hebrew scriptures know, one of their commonest features, and is often a great help in exegesis. It gave rise to a good deal of the historical etymology of proper names.

In light of this well known fact it cannot be uninteresting to notice that the term *branch*, or *offspring*, or *child* (applied by the men of the synagogue to the expected Messiah, who should rebuild the temple, and set up his throne) corresponds exactly to the Egyptian etymology of the name of the original Messiah, Moses, *Child*.

The hebrew traditional etymology of the name Moses (Ex. 2 : 10) was evidently constructed on the story of his infancy ; "for I have drawn him out of the water" (ci m'n h'mim m'shithu). And the Egyptian colony of Jews to whom we owe the old greek translation, spelled the name MS'E in a complex manner, μωυσῆς, apparently for the purpose of justifying that etymology, and introducing into it the idea of water.

But in so doing they had to neglect the real point of the etymology in Exodus 2 : 10, where the participle "*being drawn out*" is the only word which carries the etymology.

The Egyptian Jews could find nothing in coptic meaning "being drawn out" to suit them, and had to use the coptic words for "*water*" and "*to save*." Hence Josephus (Ant. 2. 9. 6 ; cont. Apion 1. 31) and Philo (2. 83) considered the name Moses to mean "*saved*," not "*drawn out of*" the water.

* Other Hebrew relatives can be found in הֵד, *hêd*, a shout and הדד, to shout with joy ; in הֵן, *hên*, lo, behold (a shout) ; and הֵנָּה (fem.) *they*, *i. q.* behold them there!

Other and more modern writers follow a somewhat different track by translating Moses, "*the Preserver.*" For while the writer of Exodus prefers the etymology in its passive form and explains that Pharaoh's daughter called him Moses because she had drawn him out of the water, —the writer of the later chapters of Isaiah (63 : 11) shows that a very different traditional etymology existed in his time, (or in his own mind perhaps), and one wholly incompatible with the other. "*Then his people bethought them* of the old days of Moses, (or, *then Moses' people bethought them of the old days*). Where is he now who once *led* them (or *drew* them) out of the sea, with the shepherd of his flock?" &c.

It is unprofitable to follow further these traditional attempts to explain the name Moses ; or rather the hebrew word *M's'h*, which bears the same relation to the greek form Moses, or Möuses, that the egyptian name of the first pharaoh M'na does to its greek form Menes.

We have the same liberty to go to the egyptian dictionary as Josephus or Isaiah or the unknown author of Exodus had ; and when we go there we find the words Mas and Massis not only meaning *child* and so used in prose and poetry, but employed as a proper name, either alone or in composition. There was an entire dynasty of Kings each of which bore the name Ra-Mes, and Ra-Messis, "child of the sun." And those who accept the account of Moses place the date of his birth precisely in the reign of the most distinguished of these sovereigns, Ramses II, the greek Sesostris, about 1400 B. C. But the egyptian records tell us that Mass, child, was not an uncommon name, worn by common people and by some in high official position. Pharaoh's daughter could not give a more appropriate name to the boy whom she had adopted as her *child*.

2. It can hardly be a coincidence that both the lawgiver and father of the nation to whom the Hebrews looked *back* with awe and gratitude, and the great deliverer and king of the nation to whom they look *forward* with hope and almost divine worship, should have borne such similar names as Moses and Messiah. In Hebrew the difference between MSH' and MSH' by which *Moses* and the *Messiah* (or the verb to *anoint*) are designated, is merely the difference between a soft and a rough breathing. On the other hand, if Moses meant *child*, and the Messiah was called *Branch*, offspring, the community of ideas becomes complete.

3. The passage in Zechariah has another attraction for the egyptologist. The prophet may and probably did suppose that Joshua, the high priest of his day, was the Messiah, so long expected, and may have called him *Zemach*, the Branch or Offspring (of David) in that hope ; but it was as high priest that he glorified him, saying *Zemach s'emo*, Branch is his name. Now this hebrew word *S'm** is curiously enough the word for the high priest of Memphis in the hieroglyphics. (Brugsch. p. 1221.)

It is written simply *SM, e. g. Sem Ptah*, chief priest of the god Ptah ; *nenek setem em arisf*, I, the chief priest among his own people ; &c.

* Masoretic. It may have been *sem*.

Sem written with the bread trough and a boat, is given (in a legend by Lepsius) as the name of a sacred bark.

Sem preceded by a hatchet or other symbols of forward movement (like the bread trough when carried on the head, or the phallus) meant "to present an aspect, to appear, to show oneself, to manifest oneself like a god," also "to show the way,* to point out, to lead." It therefore strictly comports with the meaning "high priest" in both an active and a passive sense.

Sem with the demonstrative of a man with his hand to his mouth, carried the idea still further, viz., to celebrate, to praise, and to bestow a benediction, *i. e.*, to exercise the three functions of a high priest.

Some years ago I saw reason for deriving the greek *συμβολον*, a symbol, from the phœnician *Shembaal*, translating it simply "name of Baal" in the sense of that which represents Baal, or more generally *a divine representation*, or *sacred sign*. This conclusion was supported by the Egyptian use of the word, as above described; as well as by the important use of the same word in the hebrew writings: *Shem Jahveh*, the "name of the Lord," *i. e.*, his representative in human speech, worship, and energy.

If now we return to the archaic history of the Jews, we find the name *Samuel* applied to the most distinguished personage of the times intervening between Moses and Joshua, and David and Solomon,—a personage reputed to be a priest prophet of the highest rank, and, in fact, the originator of that "School of the prophets," that caste of Jewish society which most closely corresponds to the caste of the scribes of Egypt; no doubt more or less modeled after it; and always more or less affiliated and in correspondence with it at the short distance of a few days' journey.

Samuel, שמואל, *Σαμουηλ*, dedicated before birth to the tabernacle, by his mother *Hannah*, was named with some direct reference to his dedication. Had this been to a god who had already revealed himself by his name Jah, *this* child of all others would have had *Jah* in his name. Instead of that the general word for god, *El*, evidently stands in his name; and, if the word be hebrew, the other element *Sam*, *Shem*, *Sam-u*, can be no other than שם "name." But whether the whole word can be translated "His name, El" or not is the question.

At first glance this seems a violent metaphor, of which even such savages as the hebrews of that day could not have endured. But after all, it would only be a very contracted form for "His name dedicates him to El;" or "He is named after EL."

But who was this El? for we cannot imagine the abstract God to be meant, any more than the pantheon Elohim.

What forbids us on the one hand to regard this particular El, as the Egyptian La, or Ra, or on the other hand as the Assyrian Bel, or "Shining Bar?" In fact, Ra, El, Bel, Bar and Baal were all one.

I propose, therefore, the etymology *Sam-Wal* שם-ואל, Shem Wal=

* With the ideograph of a road and pair of legs, it meant "the way or path" (well known to all and easily followed). Compare the allied latin verbs DICere, DOCere, DUCere, showing the connection of the Bard and Baron ideas.

Shem Baal, instead of שמו-אל, Shemu El = His name El; and support it by the following arguments :—

1. The harshness of the construction if *Shem-u* be translated His name; to say nothing of the lack of analogies for such a composition. What is there in Greek for instance like *Ονομαθεος* or *Ονομαθεοδατος*, or *Ονομαυτουθεος*, or any possible such construction for a personal name? We have Numa, Numitor, and Numenius, suggestive of *Numen*, but not a latin proper name compounded with *Nomen*. Such a name as Nomentanus, like Numantianus was geographical and not mythological.

2. Of the same age as *Samuel* was *Samson*, שמשון, in which etymologists find *Shemesh* the Sun, and *Un* or *On*, untranslatable, but probably meaning *light*.* But if *Samuel* means "Name of him El," Samson should mean "Name S'un, or S'on." (C. Chiun, Amos 5 : 26.)

3. *Shem* in hebrew means *Sign*, like *σημα* in greek. Some look on it as an abbreviated שמע, ShMO, *to hear, something heard*, which the LXX not unfrequently translates by *ονομα* (Gesenius). Hence *Shem*, *name*, ex. *Shem* Jehovah, Name of the Lord, &c. But if the meaning "Name" be inapplicable in *Samuel*, the meaning "Sign" is very applicable; and we could not have a better etymology than "Image of El" for the boy prophet. But this necessitates the change of El to Vel, or Bel; and "Image of El," to "Image of Bel;" in other words, the greek *Συμ-βολ-ον*, borrowed from the Shem-Baal of the Phœnician traders.

4. We have this form contracted in the curious phrase פסל הסמל, *pesel ha* SEMEL, "Statue (cutting) of likeness" literally, "Statue portrait," "carved image," "stone symbol," of Deut. 4 : 16 and 2 Chron. 33 : 7; also Ez. 8 : 3, 5.

And in another equally curious form שמאל, the left, the left side, the *north;* when we remember that the ancient pantheon sat in the sides of the north, in the hill of the north; while the Sabæon mythology had for its symbol of symbols, the pole star and the Great Bear.

Before leaving the subject, I would suggest the possibility of an etymology from צוה TsVE to command, rule, a precept; compared with a very characteristic SM *to command* in Egyptian (see Birch in Bunsen, Eg. V, pp. 508, 509, and I, p. 567) *Sem*, chief, deputy; *Samsu*, king's deputy, provincial nobleman, represented by the spade, and a man holding the *suten* or royal plant in his right hand. Hence *Sam't* to establish.† Another Hebrew form of the word is שבע, S'BO, not radically differing from the other; and a third form, also radically identical with the other two, and equally referrable to the more ancient Egyptian form, is שפט S'PT, meaning to command, not as a deputy, but as a judge. And in this we find ourselves returned to *Samuel* as the great Judge in Israel.

* AUR is light; AUN—On, the city of the Sun in Egypt, called by Jeremiah (who went to Egypt) Beth Shemesh, house of the Sun; by the greeks, Heliopolis, city of the Sun; by the Arabs, fountain of the Sun (mistaking AUN for AIN); in Coptic, *ouein*, *orin*, *oudini*, light.

† Curiously enough the same word was used for a conspirator, with various ideographs signifying punishment for malfeasance in office.

Stated Meeting, June 17th, 1881.

Present, 5 members.

Vice-President, Mr. E. K. PRICE, in the Chair.

A letter accepting membership was received from Mr. James A. Murray, dated Mill Hill, Middlesex, N. W., England, May 7, 1881.

A letter acknowledging the reception of his diploma was received from Mr. C. H. F. Peters, dated Hamilton College, Clinton, N. Y., June 14, 1881.

A letter acknowledging Transactions Vol. XV, No. 3, was received from the Smithsonian Institution.

Permission was granted to Major Jed. Hotchkiss, of Staunton, to use a wood-cut.

Acknowledgments were received of the receipt of Transactions, XV, No. 3, from the Smithsonian Institution, and of Proceedings, from the Austrian Acad. (104, 105); Bavarian Academy (104, 105, 106; List); American Statistical Association (105, 106, 107; List); Connecticut Historical Society (108); American Antiquarian Society (108); Boston Public Library (108); New Hampshire Historical Society (108); Essex Institute (108); Rhode Island Historical Society (108); New York Historical Society (108); New Jersey Historical Society (108); New York Hospital (108); American Ethnological Society (108); Astor Library (108); Maryland Historical Society (108); H. Phillips, Jr. (108); Pennsylvania Historical Society (108); J. F. Carll (108); J. H. C. Coffin, W. B. Taylor, Washington D. C. (108); Georgia Historical Society (108); R. Peter, Lexington, Ky. (108); J. M. Hart, Cincinnati, Ohio (108).

Letters of envoy were received from the Academies at Vienna and Munich, Breithoff and Härtel, at Leipsig; the Holland Society, at Harlem; Musée Guimet, at Lyons; N. G. d. O., at Altenburg; the Manchester Literary and Philosophical Society, and the Department of the Interior of the United States, Washington, D. C.

Donations for the Library were received from the R. and I.

Academies at St. Petersburg, Berlin, Vienna, Munich, Göttingen and Rome; from the Societies at Görlitz, Leipsig, Offenbach, Altenburg, St. Gall, Harlem, Manchester, Glasgow, Quebec and Montreal; from Professor William Whitney, from Leipsig; the Archives at Nijmegen; the Geological and Horticultural Society at Berlin; the Zoölogical Garden at Frankfort; the Paris Geographical Society; Revue Politique; Annales des Mines; Museum of Natural History; Bureau of Longitudes; Observatory; Anthropological Society; M. Claud. Jannet; from the Academy and Geographical Society at Bordeaux; from the Observatories at Prag, Munich, San Fernando, Oxford, Stockholm and Washington; the Trigonometrical Survey of India; the Department of Mines; the Royal Society of New South Wales and Archibald Leversidge, at Sidney; the Inspector of Mines, Melbourne; the Royal Institution of Great Britain, Royal Astronomical Society, Royal Geographical Society, Geological Society, Royal Asiatic Society, Editors Nature, the Chemist's Journal, Steven's Historical Collection and Journal of Forestry, at London; the Natural History Society of Northumberland; the Radcliff Observatory; the Literary and Philosophical Society, at Manchester; the Philosophical Society, at Glasgow; the Royal Geological Society of Ireland; the Literary and Historical Society of Quebec; the Canadian Naturalist; the Museum of Comparative Zoölogy, at Boston; the American Journal of Science; the Peabody Academy of Science; Professor E. D. Cope, the Franklin Institute, the Medical News and Journal of Pharmacy, Thomas Meehan, Henry Phillips, Jr., at Philadelphia; the Peabody Institute, at Baltimore; the Chief of Engineers U. S. A., the Smithsonian Institution, Bureau of Education, United States National Museum, Rear Admiral John Rodgers, Edward C. Pickering and Albert S. Gatchet, at Washington; from Major Jed. Hotchkiss; the Geological Survey of Kentucky; Wabash College; the Historical Society of New Mexico and the Ministerio de Fomento, in Mexico.

Professor I. C. White communicated a paper entitled "Notes on the Geology of West Virginia; a rectification of the Sec-

tion made by Mr. Howard Grant Jones, and published, under the title, Notes on the Cumberland or Potomac Coal Basin," in the Proceedings, No. 107, pages 111 to 116.

Professor P. E. Chase communicated a paper entitled "Photodynamic Notes, III," including "A Series of Natural Standard Units for gravitating, luminous, thermal, electric and chemical comparison."

Dr. George A. König communicated a paper "On *Alaskaite*, a new member of the series of bismuth sulpho salts," as a "contribution from the University of Pennsylvania."

Pending nominations Nos. 934 to 936 and new nominations Nos. 937 to 940 were read.

Permission was given the Librarian to permit Professor Richards, of the University of Pennsylvania, to take from the library three volumes of Bouillon for the purpose of photographing the engravings for his lectures.

The Secretaries were authorized to furnish Mr. Henry Phillips, Jr., one of the Curators, with a letter introductory to foreign correspondents of the Society.

And the meeting was adjourned.

Notes on the Geology of West Virginia. By I. C. White, Professor of Natural History in the University of W. Va.

(Read before the American Philosophical Society, June 17, 1881).

*A Rectification of the Section made by Mr. Howard Grant Jones, M.S., and Published under the Title of "Notes on the Cumberland or Potomac Coal Basin," in Proc. A. P. S., No. 107, pages 111–116.**

The results at which Mr. Jones arrived concerning the duplication of No. XI along the North Potomac river, in his paper read before this Society last year, were so startling, and so much at variance from my own limited knowledge of the geological structure in that region, that I determined to investigate the question anew at the first opportunity. During May of the present year, in company with some members of my class in Geology at the University, we took a five days' excursion through the Piedmont Keyser region, and the present paper is the result.

As will be seen from the sequel, that part of Mr. Jones' section below No. XII is erroneous.

* Read September 17th, 1880.

I find *no duplication of No. XI*, the "2000′ red shale," which Mr. Jones placed in No. XI, being Catskill, separated from the true No. XI by 1150′ of gray Pocono (Vespertine) (X) sandstone; his "440′ Lower Mountain Limestone" is *Lower Helderberg* (No. VI); his *"100′ Pocono sandstone" is the White Medina, more than 10,000′ below the true Pocono.*

The line of section extends from Piedmont, Mineral county, West Virginia (and Westernport, Maryland, just opposite), south-eastward along the West Virginia side of the North Potomac, to Keyser (formerly New Creek), and one and a half miles beyond to the summit of Knobby mountain ("Knobbley").

A reference to the accompanying figure will explain the structure of the rocks along the section line which is not far from six and a half miles in length.

As is well known, the Cumberland, or Potomac Coal Basin, lies in a trough of the Allegheny system with Savage mountain bounding its north-western rim, and Dan's mountain* its south-eastern. The North Potomac, after flowing north-eastward down this great syncline for many miles in West Virginia, receives the Savage river at Bloomington, near the Maryland line, whence the combined stream flows eastward across the Basin to Piedmont, two miles below, and then veering to the south-eastward cuts squarely through the Dan's Front Ridge mountain, continuing on across the upturned edges of X, IX, and VIII to Keyser, when trenching through an arch of VII, and the upper portion of VI, across New Creek mountain (ridge), it again flows north-eastward along the north-western slope of Knobby mountain to Cumberland.

From an inspection of the figure, it will be observed that the strata are almost horizontal in the vicinity of Piedmont, and Westernport; that in going south-eastward they soon begin to rise quite rapidly, the lowest beds of No. XII coming up to the south-east at an angle of 12°, three-fourths of a mile below Piedmont. Nos. XI, X, IX, and VIII come up successively with constantly steepening dips until near the middle of VIII, the rocks are vertical; finally near Keyser the Oriskany sandstone, No. VII, comes up with a diminished dip, and arching over the anticlinal axis of New Creek mountain, barely dips down to water level on the North Potomac, making a very shallow and sharp syncline, since it immediately returns with a reverse dip of 65° to the North-west, which carries No. VII, VI, and V into the air over the Walker's ridge anticlinal, one-half mile south-east, to come down again on a south-east dip in the monoclinal range of Knobby mountain, whose crest is formed by the *Oriskany sandstone* (No. VII), and the underlying cherty layers at the top of the Lower Helderberg (No. VI), the varying composition and unequal hardness of which give rise to the peculiar topography that has given name (Knobby) to the range.

A more general discussion of the data in this section is reserved for a

*On the West Virginia side of the Potomac the continuation of this range is called the Allegheny Front Ridge.

future paper. The intervals in the following section were measured directly down to 700' below top of the Mauch Chunk red shale, with one of Hick's compensated aneroids, the rest of the section being obtained by calculation from the observed dips and measured horizontal distances. The thicknesses thus arrived at are deemed rather under than above the truth, since a small percentage of error must necessarily enter into the construction of every such section.

1.	Massive sandstone, coarse grayish-white, most probably equivalent to one often found in Greene Co., Pa., 100' below the Waynesburg coal. It caps the summit of Westernport hill	25' 0"	Upper Coal Measures 398'
2.	Mostly concealed, but showing some outcrops of flaggy sandstone and shale	130' 0"	
3.	*Coal blossom*, large, Sewickley ?	-	
4.	Concealed	90' 0"	
5.	Shale, grayish	2' 0"	
6.	Pittsburgh Coal at Franklin Co.'s new opening, Westernport Hill. *Coal*, impure .. 0' 8" Dark slate ..... 4' 0" *Coal*, slaty .... 1' 0" Shale, grayish . 1' 0" (Roof coal .. 6' 8") *Coal*, main bench, no partings, all good 10' 0" Slate .... 0' 2" *Coal*, good .... 0' 10" Parting .... 0' ¼" *Coal*, not mined 2' 0" (Bottom coal 3' 0")	19' 8"	
7.	Dark slate	0' 6"	Barren Measures 600'
8.	Soft carbonaceous shale	0' 2"	
9.	Shales, drab	15' 0"	
10.	Sandstone, flaggy, and shaly	25' 0"	
11.	Concealed	140' 0"	
12.	*Coal*, blossom. *Elk Lick ?*	-	
13.	Concealed	100' 0"	
14.	*Coal*, blossom		
15.	Concealed	140' 0"	
16.	*Coal*	4' 0"	
17.	Concealed	35' 0"	
18.	Sandstone, massive, pebbly. Upper Mahoning	30' 0"	
19.	Concealed, with a *coal* reported 4' thick just below top of the interval	90' 0"	
20.	Lower Mahoning S. S., massive, visible	20' 0"	
21.	Concealed	10' 0"	
22.	*Coal*, *Upper Freeport* .... Mr. Spangler's opening, Westernport hill. Coal .... 2' 0" Shale, gray .. 1' 0" Coal .... 2' 0"	5' 0"	
23.	Concealed	10' 0"	

24. Shale, bluish	10′ 0″	Lower Productive Coal Measures.	
25. *Coal*	2′ 6″		
26. Fireclay	2′ 0″		
27. Concealed	10′ 0″		
28. Sandstone, very hard	2′ 0″		
29. " shaly	5′ 0″		
30. Shales, sandstone and concealed	55′ 0″		
31. Dark bituminous shales	5′ 0″		
32. *Coal*, visible	2′ 0″		
33. Dark shales and concealed	10′ 0″		
34. Very massive sandstone, Lower Freeport	50′ 0″		268′
35. Shales, drab	0′–5′ 0″		
36. *Coal* { Middle Kittanning / Darlington } Mr. Spangler's opening in Westernport hill. { *Coal*, slaty ... 1′ 0″; Bony coal.... 0′ 8″; Coal, pyritous 1′ 4″; Slate, hard... 0′ ½″; Coal, best.... 2′ 6″ }	5′ 6½″		
37. Fireclay, very sandy	3′ 0″		
38. Shales with nodular *iron ore*	2′ 0″		
39. Fireclay, impure	4′ 0″		
40. Flaggy sandstone	20′ 0″		
41. Concealed	25′ 0″		
42. Fireclay, very sandy and impure	10′ 0″		
43. Flaggy sandstone	10′ 0″		
44. Sandy shales	15′ 0″		
45. Massive sandstone { Piedmont / Homewood }	20′ 0″	No. XII, or Conglomerate	
46. *Coal*	2′ 0″		
47. Dark shales, containing many fossil plants, *Pecopteris dentata*, *P. polymorpha*, *Neuropteris flexuosa*, *N. acutifolia*, *Odontopteris* sp.? and many other common *Coal measure* forms; also many nodules of "Kidney" *iron ore*, all seen in cutting at Davis's bridge (Saw mill road) opposite Piedmont	45′		
48. Sandstone, hard, somewhat current bedded, inclined to be flaggy, weathering in holes, seen in cliff to level of North Potomac, at Piedmont, just above the C. & P. R. R. bridge	40′ 0″		
49. Dark shales (coaly) and concealed	30′ 0″		
50. Sandstone, flaggy	10′ 0″		
51. Shale, dark olive	2′ 0″		
52. *Coal*	1′ 6″		
53. Fireclay, dark, sandy	12′ 0″		
54. Sandstone, flaggy, with *coal streaks*	10′ 0″		
55. *Coal*	1′ 6″		
56. Shale with nodular *iron ore*	2′ 0″		451′
57. Shales and flaggy sandstone	40′ 0″		

No.	Stratum	Thickness	
58.	Massive, very hard, grayish-white fine grained sandstone, with some small pebbles, exhibiting in its lower portion between the layers, at intervals of 2′ to 3′ a kind of imperfect crystallization, by which a vertical section through the layers much resembles along the bedding planes the large interlocking teeth of an animal. This peculiar structure was observed at localities 2 ms. distant, and seems to be characteristic of this stratum in the Piedmont region. Seen forming a long line of cliffs on the Maryland side of the Potomac, 1 mile below Piedmont, and also capping the summit of the Front Ridge Allegheny on the W. Va. side, 2 ms. below Piedmont	45′ 0″	Measures.
59.	*Coal shale*	5′ 0″	
60.	Concealed with some shale and flaggy S. S. visible	145′ 0″	
61.	Sandstone, massive	10′ 0″	
62.	Bituminous shale	10′ 0″	
63.	Sandstone, flaggy	10′ 0″	
64.	Sandstone, massive, whitish (base of XII)	20′ 0″	
65.	*Coal*, seen at roadside along the Maryland shore of North Potomac, 1 m. below Piedmont	1′ 0″	Umbral (No. XI), 852′ or Mauch Chunk Shales.
66.	Sandstone, drab	4′ 0″	
67.	Fireclay and shale	3′ 0″	
68.	Sandy shale	4′ 0″	
69.	Shales, brown, containing *iron ore*	10′ 0″	
70.	*Red shale*	10′ 0″	
71.	Sandstone, flaggy, greenish-gray, with much shale	40′ 0″	
72.	Concealed	40′ 0″	
73.	Sandstone, somewhat massive, greenish-gray	20′ 0″	
74.	Concealed, but showing occasional appearances of *red shale*, and very probably largely composed of that material	375′ 0″	
75.	Sandstone, somewhat massive, but often inclined to be flaggy, greenish-gray; seen in cliffs along the B. & O. R. R. cuts, near the 205th mile post from Baltimore, below Piedmont	130′ 0″	
76.	*Red shales*	35′ 0″	
77.	Shales, greenish, sandy	20′ 0″	
78.	*Red shale* to level of B. & O. R. R. track at little run 76 rods east from the 205th m. p. from Baltimore	10′ 0″	
79.	Concealed	150′ 0″	
80.	Limestone, gray, fossiliferous, containing *Spirifer keokuk, Athyris sub-quadrata, Productus cora, Hemipronites crassus*, and many *Crinoidal* fragments	10′ 0″	Mountain Lime
81.	Concealed, but probably containing several layers of limestone	90′ 0″	
82.	Limestone, gray, massive	5′ 0″	

Proc. Amer. Philos. Soc., Vol. XIX. No. 109.

Section from the eastern escarpment of Savage Mt. through Westernport (Md.) hill crossing to the W. Va. side of the North Potomac at the mouth of Georges Creek, and continuing along the same S. 25 E. to the summit of Knobby Mt.

Scale 6000' to an Inch.

Second Geological Survey of Pennsylvania.

Constructed May 1881 by Prof. I. C. White.

83. *Red shales* and concealed........................... 140′ 0″
84. Sandstone, coarse, brownish, visible................ 5′ 0″
85. Concealed.. 50′ 0″
86. Limestone, grayish-white, no fossils seen............ 10′ 0″
87. *Silicious Limestone* (of Stevenson in Fayette and Westmoreland, Pa.), exhibiting a wavy or current bedded structure and giving forth a metallic resonance when struck with hammer................................ 80′ 0″

340′ stone (No. XI.)

88. *Vespertine, Pocono,* or *No. X*, consisting of gray, current bedded, mostly flaggy sandstones, no conglomerates seen, nor red shales; rising at an angle of 18°—20° towards the S. E. and extending along the B. & O. R. R. for 58 chains, the lowest layers rising above R. R. level 38 chains east from the 204th Baltimore m. p. Thickness, about.................................1150′
89. *Catskill*, or *No. IX*, consisting of dark red shales alternating with red, and greenish-gray sandstones, containing *fish remains*, but no molluscan seen; rising towards the S. E. at an angle of 25° at top and 35° where the bottom layers come up 7 chains west of the 203d m. p. thus making a vertical thickness of, say...1300′
90. *Chemung*, consisting of alternate layers of thin, olive sandstones, and shales, very fossiliferous, and perfectly exposed along the B. & O. R. R. in vicinity of 203d m. p.; coming up towards the S. E. at an angle of 35°, and at the end of 10½ chains the dip is increased to 45°, thus giving an approximate thickness of Chemung down to this point of about............400′
91. *Conglomerate*, composed of very thin, flat, rounded quartz pebbles, in a matrix of coarse rotten sand with numerous fossil shells imbedded, very forcibly reminding one of the Venango Lower (3d) Oil Sand; thickness.. 2′
92. Chemung flaggy sandstones and shales continue rising at an angle of 45° for 16 rods further towards the S. E. all perfectly exposed, and very fossiliferous; thickness about.......................................200′

Rocks certainly 602′ Chemung.

93. Concealed, 13½ chains, at the end of which the strata are rising at an angle of 62° towards the S. E. thus making the intervening rock thickness about.................................. 700′
94. *Conglomerate*, a gray, hard sandstone, containing numerous layers filled with flattish, white quartz pebbles............... 40′
95. As we go S. E. from this point toward Keyser, the rocks rapidly increase their dip to the N. W. and at ½ mile from the outcrop of No. 94, are vertical; continuing thus or even slightly bent over beyond the perpendicular to the end of 100 chains (1¼ ms) from No. 94. Exposures are rare in this interval, as there are

seldom more than 5′—10′ exposed at any one locality, and these are in every case olive, and drab colored shales. The topography also shows that no hard nor massive rocks occur in this interval, since on entering it the mountain immediately breaks down to the S. E., giving a broad valley along the Potomac, bordered by gently sloping hillocks. The interval includes all the rest of No. VIII, whatever there may be of *Portage, Hamilton* and *Corniferous*, and its thickness cannot be less than.......................................6000′

96. *Oriskany Sandstone* (No. VII), rises above the North Potomac nearly opposite the dèpot at Keyser, and arching up over New Creek ridge (mountain) forms the bold cliff at Queen's point, opposite Keyser, 400′ almost vertically above the river; a very coarse, brownish sandstone, filled with its characteristic fossils, *Spirifer arenosus, Rensaelaeria ovoides* and *Platyceras ventricosum;* it comes down to the river at the R.R. cut a short distance east from Keyser, with a strong south-east dip, but immediately returning it comes up again with a strong N. W. dip (65°), and arching up passes in the air over the next anticline to come down again along the (monoclinal) crest of Knobby mountain ("Knobbley"). Thickness.............................. 75′

97. *Lower Helderburg* (No. VI); at top a gray silicious limestone, with several layers of flint 6″—10″ thick, interstratified for about 150′, then follow blue and gray layers of pure limestone richly *fossiliferous, Strophomena radiata, S. rugosa, Pentamerus pseudo-galeatus, Rhynchonella ventricosa, Spirifer macropleurus, Atrypa reticularis, Tentaculitus ornatus, Leperditia alta,* besides numerous species of *Favosites, Zaphrentis, Stromatopora,* and *Chætetes,* being very abundant. Very fine *Trilobites* are also reported from some of the quarries, which from their (reported) size must be species of *Asaphus.* This is the limestone which was identified in H. G. Jones's section as the *Lower Mountain Limestone* of XI, and 440′ thick. My measurements make it much thicker, however; it is finely exposed along Limestone run one-half mile S. E. from Keyser; it makes the N. W. slope of Knobby mountain all the way between Keyser and Cumberland, the upper silicious layers often forming the irregular crest of the same; its uppermost 300′ are also exposed under the great arch of Oriskany Sandstone at Queen's point opposite Keyser, where the North Potomac cuts through New Creek mountain. The fossils given were all seen in the upper portion of the formation. No attempt was made to subdivide the series, which consists of limestone throughout, the measurement of which south-eastward along Limestone run gave the horizontal distance through it 18 chains, with a N. W. dip of 63°, which would give a thickness of......................1050′

98. A succession of shales, marls and thin shaly limestones, with occasional brown flaggy sandstones; near the centre of which occur very strong *salt springs* from which considerable salt was formerly manufactured, the whole representing the *Salina group* of New York. Thickness about.................... 850′

99. (*a*) Hard gray flaggy sandstone, 20′, then follows

(*b*) a succession of brownish sandy shales with a few thin layers of impure limestone near the centre, and two layers of *iron ore*, the one 6″ the other 12″ thick, and separated by 10′ of shales, 50′ below the centre; thickness about 300′. Then comes

(*c*) the main mass of the *Clinton fossil iron ore* 20′ thick, quite rich in iron, but entirely too silliceous; once shipped from the land of Mr. N. Alcaire on Limestone run by Uniontown, Pa., parties to Lemont Furnace and one or two in Pittsburgh, but after a thorough trial condemned by them all as too silliceous.

(*d*) Shales, 40′ thick.

This whole group (*a, b, c, d*), and probably a portion of the overlying 350′ in No. 98, representing whatever there may be of Niagara (if any) and all of the *Clinton* (No. V); entire thickness (*a, b, c, d*).. 380′

100. *Medina Sandstone* (No. IV in part), seen forming the lowest rocks in the ridge (anticlinal) half way between New Creek mountain and Knobby range, the upper portion reddish brown to gray iron-stained sandstone, containing *Anthrophycus harlani* in great numbers, thickness 150′; lower portion an almost snow-white, very hard, fine grained sandstone, some portions slightly streaked with iron, thickness 125′; finely exposed on Limestone run, one mile above its mouth where that stream cuts through the Walker's Ridge axis. This is the stratum which Mr. H. G. Jones identified as the *Pocono*, or white sandstone of X, the 100′ sandstone with which his section ends (see Proc. A. P. S. Vol. XIX, No. 107, page 116). (On the B. & O. R. R., one mile west from Brady's Mills, 15 miles east from Keyser this white sandstone is seen in a R.R. cut 100′ thick, and below it 500′ of drab, brown, and bluish shales ending in flaggy sandstones at base.) Entire thickness of Medina at Keyser to base of white sandstone............. 275′

SUMMARY.

Carboniferous.

Upper Coal measures (XV)		268′	3929′
Barrens (XIV)		600′	
Lower Coal measures (XIII)		268′	
Conglomerate measures (XII)		451′	
Mauch Chunk shale 852′	(XI)	1192′	
Mountain Limestone 340′			
Pocono (Vespertine) (X)		1150′	

Devonian.			
Catskill (IX)		1300′	8717′
Chemung, Portage, Hamilton, Upper Helderburg (Corniferous)	(VIII)	7342′	
Oriskany Sandstone (VII)		75′	
Upper Silurian.			
Lower Helderburg Limestone (VI)		1050′	2555′
Salina, Niagara?, Clinton	(V)	730′	
Medina Sandstone 275′, Medina shales * 500′	(IV) (in part)	775′	
Total height of section			15,201′

Photodynamic Notes, III. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(Read before the American Philosophical Society, June 17, 1881.)

46. *Stellar Relations of the Corona Line and of Mass.*

The laws of harmonic æthereal oscillation, which fix planetary nodes within the solar system in accordance with spectral lines (Note 37), should also be manifested between stellar systems. Such a manifestation is found in the proportion

$$1^2 : (316.53+1)^2 :: 460 : 46,379,800 \qquad (1)$$

In this proportion, the mass at the centre of condensation (Earth) is represented by 1; the mass at the centre of nebulosity (Jupiter) by 316.53; the distance of *a Centauri* by 46379800; the distance of Earth's nascent locus (Note 45) by 460, or the cosmical equivalent of the corona line. The square of the mass varies as reciprocal *vis viva*, or orbital *vis viva* at uniform distance, and also as distance of orbital projection at uniform distance against uniform resistance.

The abscissas of the stellar-solar paraboloid may therefore be computed by means of Sun's semi-diameter, Laplace's limit, and the corona line, as follows:

$$v_\lambda = 214.45\, r_0 \div 497,827 = .4307721\, r_0 \qquad (2)$$

$$v_0 = 2\pi\, r_0 \times 214.45^{\frac{3}{2}} \div 31558149 = .0006252556\, r_0 \qquad (3)$$

$$g_0 = v_0^2 \div r_0 = .0000003909446\, r_0 \qquad (4)$$

$$t_r = 2v_\lambda \div g_0 = 2203750 \text{ sec} \qquad (5)$$

* Seen near Brady's Mills, 15 miles east from Keyser.

$$L = 214.45 r_0 \left(\frac{t_r}{1 \text{ year}}\right)^{\frac{2}{3}} = 36.3658 r_0 \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$M = \left(\frac{r_\lambda}{r_0}\right)^2 r_0 = 474657.14 r_0 \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$\log.\ \xi = \log.\ \tfrac{1}{6} = -\ .7781513$

$\log.\ \xi + \log.\ 19\eta + \log.\ 361\zeta = \log.\ (\tfrac{1}{6}L) = 1.2085109 \ldots\ldots\ldots$

$\log.\ \xi + \log.\ 39\eta + \log.\ 1521\zeta = \log.\ [(317.58)^2 \times 460.002] = 7.6663302.$

$\therefore \qquad \log.\zeta = .0055982.$

$\log.\eta = -.0018046316.$

The following table gives the logarithms, both of the centripetal and the centrifugal abscissas, as calculated by the formula:

$$\log.\ A_n = \log.\ \xi \pm n \log.\ \eta + n^2 \log.\ \zeta.$$

n	Centripetal, ($\log.\ \xi + n \log.\ \eta + n^2 \log.\ \zeta$).	Centrifugal, ($\log.\ \xi - n \log.\ \eta + n^2 \log.\ \zeta$)
0	—.7781513	—.7781513
1	—.7743577	—.7707485
2	—.7593678	—.7521492
3	—.7331814	—.7223536
4	—.6957986	—.6818616
5	—.6472195	—.6291781
6	—.5874430	—.5657883
7	—.5164719	—.4912071
8	—.4343036	—.4054294
9	—.3409388	—.3084554
10	—.2363776	—.2002850
11	—.1206200	—.0809182
12	.0063339	.0496451
13	.1444843	.1914047
14	.2938311	.3443607
15	.4543742	.5085132
16	.6261138	.6838620
17	.8090498	.8704072
18	1.0031821	1.0681480
19	1.2085109	1.2770869
20	1.4250361	1.4972213
21	1.6527576	1.7285529
22	1.8916756	1.9710794
23	2.1417900	2.2248030
24	2.4031007	2.4897231
25	2.6756079	2.7658395
26	2.9593115	3.0531523
27	3.2542114	3.3516616
28	3.5603078	3.6613672
29	3.8776006	3.9822692

	Centripetal.	Centrifugal.
30	4.2060898	4.3143676
31	4.5457753	4.6576625
32	4.8966573	5.0121537
33	5.2587357	5.3778413
34	5.6320104	5.7547254
35	6.0164816	6.1428058
36	6.4121492	6.5420826
37	6.8190131	6.9525559
38	7.2370735	7.3742255
39	7.6663302	7.8070915

In each set, the nine abscissas from 12 to 20 inclusive, and the nine from 30 to 38 inclusive, have no obvious* significance, except as indicating a symmetrical division of the abscissas, into three groups of 3^2 each, between the star and the Sun's surface. The nine from 21 to 29 inclusive indicate different planetary influences in the two sets, which seem to be worthy of further study. If we take the anti-logarithms and divide by 214.54, in order to get the abscissas in terms of Earth's semi-axis major, we find the following accordances :

n	Centripetal.	Planetary loci.		Centrifugal.	Planetary loci.	
21	.210	$\frac{1}{2}$ Mercury,	.199	.250	Mercury s. p.,	.297
22	.363	$\frac{1}{2}$ Venus,	.362	.436	" m. a.,	.456
23	.646	$\frac{2}{3}$ Earth m. p.,	.644	.782	Venus s. a.,	.774
24	1.180	$\frac{3}{4}$ Mars,	1.142	1.440	Mars m. p.,	1.403
25	2.209	$\frac{4}{5}$ Asteroid 55,	2.208	2.720	Asteroid 45,	2.720
26	4.246	$\frac{5}{6}$ Jupiter,	4.336	5.270	Jupiter,	5.203
27	8.374	$\frac{6}{7}$ Saturn,	8.176	10.479	Saturn s. a.,	10.343
28	16.943	$\frac{7}{8}$ Uranus,	16.786	21.382	Uranus s. a.,	20.679
29	35.178	$\frac{7}{6}$ Neptune,	35.040	44.765	$\frac{2}{3}$ Neptune m. p.,	44.598

The foregoing table furnishes the following indications :

1. That there are harmonic influences upon relative mass and position extending from the stars to the Sun, of a similar character to those which are manifested within the solar system.

2. That these are the only known and measurable evidences, which have yet been discovered, of inter-stellar action.

3. That the influences are of such a character as are required by the resistance of nodes of great comparative inertia in a highly elastic vibrating medium.

4. That there is, therefore, some inter-stellar medium, to which the laws of elastic action and reaction are applicable.

* We find, however, upon examination, that log. A_{38}, 7.2370735)) is equal to log. L + log M, or log. LM, (1.5606934 + 5.6763800). This gives four elements for determining the paraboloid, where only three are required. Any three of the elements furnish data for determining the masses of Sun, Jupiter and Earth; Sun's volume and density; Laplace's limit; solar modulus of light; corona line; stellar distance and the rupturing planetary loci.

5. That the inter-stellar radial influences are so modified, by mutual action and re-action, as to become paraboloidal.

6. That the centripetal influences tend to produce and maintain nebular condensation, planetary segregation and orbital revolution.*

7. That the centrifugal influences tend to produce and maintain mean or apsidal positions for the condensed planets.

8. That the harmonic waves are propagated with the velocity of light.

9. That the controlling mass of the whole solar system (Sun), as well as the subordinately controlling masses of the extra-asteroidal and intra-asteroidal belts (Jupiter, Earth), are harmonically dependent upon the oscillations of the inter-stellar medium.

10. That the corona-, hydrogen-, and basic-lines serve to link cosmical with chemical, molecular, and other physical phenomena.

11. That the outermost known planet (Neptune) gives evidences of nebular influence, in its centrifugal as well as in its centripetal abscissa, the centripetal coefficient being the reciprocal of Saturn's, and the centrifugal coefficient being the reciprocal of Earth's centripetal. The centrifugal abscissa represents the locus of a nebular surface which would yield planetary aggregation in Neptune's orbit, through subsidence-collision.

12. That the centre of condensation (Earth) has no special centrifugal abscissa.

13. That the centrifugal abscissas for Venus and Mars point to early apsidal stages of central condensation.

14. That Earth's centripetal abscissa represents the locus of belt-formation in a nebula extending to Earth's mean rupturing locus (mean perihelion).

15. That the elements of the controlling paraboloid are all maxima, r_0, (Sun's semi-diameter), being the locus of greatest gravitating energy; L, (Laplace's limit), the limiting locus of greatest possible atmosphere; Jupiter and Earth, the greatest and controlling masses of their respective belts.

16. That the velocity of light and Sun's mass, upon which r_0 and L depend, are also maxima, and all physical phenomena within the system should be in harmonic dependence upon their mutual actions and reactions.

47. *Physical Units of Nature.*

In the Philosophical Magazine for May, 1881, Dr. Stoney republishes a paper on physical units, which he read before the British Association in 1874, giving approximate values for L_1, T_1, M_1. More than five years before his original paper was read, I had communicated to the American Philosophical Society† the equation, $u = g_1 t_1$, in which $u =$ velocity of light, which Stoney represents by $V_1 = 3$ VIII metres per second; $g_1 =$ acceleration of gravity at Sun's equatorial surface; $t_1 = \frac{1}{2}$ time of solar rotation.

*See ζ, *ante*, pp. 205-6.
†Proc. A. P. S., xi, 106-7.

This equation furnished the data for computing a less arbitrary series of natural units, L_0, T_0, M_0. The British Nautical Almanac gives an estimate of Sun's apparent semi-diameter. (r_0), which makes Earth's semi-axis major equivalent to 214.45 r_0. Hence we find (see foregoing note):

$V_0 = V_1 = v_\lambda = .4307721\ r_0 = 3$ VIII metres.
$r_0 = .0006252556\ r_0 = 435443$ metres.
$G_0 = .0000003909446\ r_0 = 272.26$ metres.

$$L_0 = \left(\frac{V_0}{v_0}\right)^2 r_0 = 474657.14\ r_0 = 33 \text{ XIII metres} = \text{solar modulus of light.}$$

$$T_0 = \frac{V_0}{G_0} = 1101875 \text{ sec.}$$

$M_0 \propto gr^2 = 331700 \oplus = 3$ XXXIII grammes.

Among the apparent advantages of these units over those of Dr. Stoney, are the following:

1. L_0 is the height of a homogeneous æthereal solar envelope, which would propagate waves with the velocity of light.

2. T_0 is the time in which the sum of the solar centripetal accelerations of maximum gravitation is equivalent to the sum of the solar reactions against the centre of gravity of all other cosmical bodies, in the alternate projection from and return towards the disturbing centre of gravity.

3. M_0 is the controlling mass of the system, and, consequently, of all the physical phenomena which occur in any part of it.

4. L_0, T_0, M_0 can be estimated more easily and more accurately than L_1, T_1, M_1.

5. G_0 is the greatest possible gravitating acceleration within our system.

6. V_0 is the greatest known velocity of wave-propagation. It is true that Wheatstone's unconfirmed experiments, as well as my own ratio of *vis viva* of excursion to *vis viva* of propagation (9 : 5), indicate greater possible velocities. But Wheatstone did not eliminate the influence of induction, and Maxwell's application of my ratio was confined to the excursion of particles through very narrow limits.

7. All of those maxima are eminently *natural* maxima, and, therefore, suitable for natural standards.

The following equations show the mutual relations of the two sets of units:

$$L_0 \div L_1 = 33 \text{ L.}$$
$$T_0 \div T_1 = 33 \text{ L.}$$
$$M_0 \div M_1 = 2 \text{ XL.}$$

48. *Rotating Vis Viva.*

The photodynamic ratio of the velocity of light to the equatorial velocity of stellar rotation is expressed, as I have shown (Note 34), by the proportion

Stellar modulus of light : stellar semi-circumference : : $v_\lambda : v_r$.

The centre of gravity of the universe must be stable, so far as any modi-

fying action of its constituent bodies is concerned. The particles of a star or nebula, exposed to ætherreal oscillations, are solicited simultaneously towards the local and towards the universal centre of gravity. The accelerations, relatively to the stellar or nebular centre, on the side towards the universal centre, and the retardations on the opposite side, necessarily produce rotation. The duration of the rotation must be such as to maintain cyclical equilibrium among the three activities of general luminous undulation, general gravitation and local gravitation.

Equality of action and reaction should lead to harmonies of *vis viva* and of mass, which may become especially prominent when there are two largely preponderating bodies in a system, as in the case of Sun and Jupiter. Their mutual actions and reactions, being exerted through a common radius, are proportioned to their masses. The mean *vis viva* of rotation being represented by a virtual projection of mass through .4 r, if we consider the modulus of light as the virtual projection due to Sun's mass during the cyclical disturbances of equilibrium, we may suppose

Sun's mass : Jupiter's mass : : Modulus : .4 Jupiter's semi-axis major.
1047.879 : 1 : : 474657.14 : 453

Jupiter's semi-axis major is 5.2028 × 214.45 = 1115.74 ; .4 of 1115.74 = 446.3.

The theoretical projection is, therefore, 1.0149525 times the mean-projection, and there is an exact accordance, twice during each revolution of Jupiter around the Sun. For, according to Stockwell,* the secular minimum value of Jupiter's eccentricity is equal to .0254928. Neptune's maximum eccentricity, according to the same authority, is .0145066, and ¼ of the mean eccentricity of Uranus is .0149588. These accordances seem significant, in view of Jupiter's central nebular position between Uranus and Neptune, at their opposition.

49. *Further Stellar Relations of Mass.*

The paraboloidal formula, $x_n = \xi \eta^n \zeta^{n^2}$, may be expressed under the form $x_n = \xi (\eta \zeta)^n \zeta^n$, the successive terms being found by the product of corresponding terms of two geometrical series. They may, therefore, be taken to represent the mutual actions and reactions of two co-ordinate masses, like Sun and Jupiter. The geometric variations of density, which accord with arithmetical variations of distance, suggest the proportion, (Note 46):

Sun's mass : Jupiter's mass : : x_{39} : 39 × Jupiter's semi-axis major.
1047.879 : 1 : : 46379946† : 44260.8

This gives, for Jupiter's theoretical semi-axis major, 44260.8 ÷ 39 = 1134.9, which is 1.017165 times the estimate of the British Nautical Almanac (Note 48). This is less than the secular minimum aphelion of Jupiter, so that the locus is traversed twice during each revolution of Jupiter about the Sun.

* Smithsonian Contributions, 232, p. 38.

† The *logarithm* of x_{39} being 7.6663302, the abscissa itself is 46379946 r_0.

If we make the greatest possible allowance for uncertainties of data, the relations of inter-planetary and inter-stellar distances to the three important masses, which are shown by the present note and the three foregoing notes, are close enough to be very curious, even if we could think them merely accidental. Inasmuch as they have been discovered by a simple consideration of the consequences which ought to follow, through the known laws of elasticity, from the interruption of luminous vibrations and the formation of nodes by cosmical inertia, they are more than curious, for they are indicative of the unity of energy which has long been thought to control all physical manifestations.

50. *Harmonic Masses.*

Twice modulus is the radius of rectilinear oscillation, which would be synchronous with orbital oscillation about a major axis equivalent to that of the homogeneous æthereal atmosphere. The dependence of modulus upon solar mass and radius makes it probable that there may be a harmonic dependence, of a like character, among the principal planetary masses. We find, indeed, that the four extra-asteroidal planets have harmonic masses, inasmuch as they may all closely be represented by the formula $\frac{\text{Sun}}{\text{Planet}} = \frac{2 \times \text{Modulus}}{n\, r_0}$, in which n is integral, so that the second member of the equation gives four terms of a harmonic progression.

$n\, r_0$	$2M \div n\, r_0$	Computed Values.	Authority.
$906\, r_0$	1047.81	1047.88 = Sun ÷ Jupiter.	Bessel.
$271\, r_0$	3503.	3501.6 = Sun ÷ Saturn.	"
$42\, r_0$	22603.	22600. = Sun ÷ Uranus.	Newcomb.
$49\, r_0$	19374.	19380. = Sun ÷ Neptune.	"

That these approximations are not accidental, may be shown by comparing the probable with the actual deviations from exact accordance.

Probable.	Actual.	P ÷ A.
$\frac{1}{4}$ of $\frac{1}{906} = .00027$	$7 \div 104781 = .000067$	4
$\frac{1}{4}$ of $\frac{1}{271} = .00092$	$14 \div 35030 = .000399$	2.3
$\frac{1}{4}$ of $\frac{1}{42} = .00595$	$3 \div 22603 = .000133$	46
$\frac{1}{4}$ of $\frac{1}{49} = .00510$	$6 \div 19380 = .000309$	17

The deviations are so far within the limits of probable errors of mass that the accordance may, perhaps, be exact. But absolute exactness, in the satisfaction of any mechanical tendencies is not to be expected. There are so many and so various modifying influences, in all cases, that any result which is in complete accordance with theory should be regarded as more suspicious than one which suggests slight perturbations from some unknown cause.

51. *Subordinate Masses.*

If "the exception proves the rule," we may find that the perturbations, which were spoken of in the foregoing note, may introduce apparent exceptions, in subordinate masses, which are really confirmatory of the har-

monic tendencies in larger masses. Taking the nearest integral values of n for each of the intra-asteroidal planets, we may construct the following comparative table :

$n\,r_0$.	$2\,M + n\,r_0$.	Computed Values.	Authority.
1	959814	3093500 = Sun + Mars.	Hall.
3	319771	331700 = Sun + Earth.	Chase.
2	479657	427240 = Sun + Venus.	Hill.
1	959314	4865751 = Sun + Mercury.	Encke.

The actual values of nr_0, which would give the computed values of mass, are .307, 2.862, 2.222, .204. There is an approximation to the integral values of n, in the cases of Earth and Venus, that of Earth having the same probability as that of Saturn, 2.3. The probability for Venus is only ½ as great, or 1.15. The masses of Mercury and Mars are evidently controlled by some other law, which overrides that of the repetition of solar radial nodes.

52. *Reciprocal Coefficients.*

I have pointed out* the reciprocity between the coefficients of the stellar-solar abscissas which indicate rupturing loci for Saturn and Neptune. This reciprocity is interesting, not only for indicating the inverse rotation of two portions of a primitive nebula, but also for introducing the harmonic ratio of mass, into the retrograde portion, which is shown in Note 50. We accordingly have the two following proportions :

$$x_7 : \rho_7 : : m_8 : m_9 : : 6 : 7.$$
$$x_9 : \rho_9 : : m_9 : m_8 : : 7 : 6.$$

In these proportions, x represents the stellar-solar abscissa, or rupturing locus ; ρ, semi-axis major ; m, mass ; subscript $_7$, $_8$, $_9$, Saturn, Uranus, Neptune.

53. *Total Planetary Mass.*

Notes 46, 48, 49 and 52 indicate the probability of some photodynamic influence in determining the primitive ratio of solar (m_0) to planetary mass (m_n). On examination we find

$$\tfrac{7}{8}\text{ modulus} : \text{Sun's semi-diameter} : : m_0^2 : m_n^2.$$
$$553767 : 1 : : 744.155^2 : 1^2.$$

The following table gives the computed masses of the several planets, Sun's mass being represented by 10,000,000,000.

Mercury,	2,055	Encke.
Venus,	23,406	Hill.
Earth,	30,148	Chase.
Mars,	3,233	Hall.
Jupiter,	9,548,087	Bessel.
Saturn,	2,855,837	Bessel.
Uranus,	442,478	Newcomb.
Neptune,	515,996	Newcomb.
Sum,	13,416,240 = m_0 + 745.365.	

*Ante, p. 209.

This value differs by less than $\frac{1}{6}$ of one per cent. from the above theoretical value. If the sum of the asteroidal and cometary masses is about $\frac{2}{3}$ as great as Earth's mass, the accordance is exact. The additional evidence which it furnishes, both of early photodynamic rupturing and reciprocally rotating influences, ($\frac{7}{6}$, $\frac{6}{7}$), may prove to be as important as it is interesting. The total planetary mass is very nearly 2×7 times the retrogradely rotating mass of Uranus and Neptune.

54. *Atomic Weights.*

The close approximation to integral mass-divisors (Notes 50, 51), in all the known primary planets except Mercury and Mars, is like the atomic approximations to exact multiples of the hydrogen unit. This fact, together with the many evidences of tendencies to harmonic wave-lengths among spectral lines, suggests the probability of harmonic influences upon atomic weight, as well as upon atomic velocity.

There is still so much uncertainty in regard to many of the atomic weights, that it is impossible to determine, with exactness, the various subdivisions of which any given element may be susceptible. It is evident, however, that certain factors enter more frequently into the atomic ratios than could be looked for from the mere laws of probability, and it does not seem unreasonable to hope for future light upon the nature of chemical combination, from the study of mathematical combinations.

The factors which seem worthy of special attention are, 2, 2^2, 2^3, 2^4, 3^2, 5^2, 7, 13. The combination of the powers of 2 with prime numbers is shown in the following table :

	1	3	5	7	11	13
2	—	—	—	N	—	—
4	—	C	—	Si	Sc	Cr
8	—	Mg	Ca	Fe	Y	Ru, Rh
16	O	Ti	Br	Cd	—	—
32	S	Mo	—	—	—	—

The following groups are also suggestive :

4×3	C	4×22	Y	7×1	Li	7×26	Ta
4×4	O	4×24	Mo	7×2	N	7×30	Bi
4×6	Mg	4×26	Ru, Rh	7×4	Si		
4×7	Si	4×27	Ag	7×5	Cl	13×3	K
4×8	S	4×28	Cd	7×8	Fe	13×4	Cr
4×10	Ca	4×35	Ce	7×9	Cu	13×5	Zn
4×11	Sc	4×45	La	7×10	Ga	13×6	Se
4×12	Ti	4×46	W	7×16	Cd	13×8	Ru, Rh
4×13	Cr	4×50	Hg	7×18	Te	13×14	Ta
4×14	Fe	4×51	Tl	7×19	Cs	13×15	Os
4×17	Ga	4×52	Bi	7×20	Ce	13×16	Bi
4×20	Br	4×60	U				

Bismuth, on account of the uncertainty of its equivalent, appears in each

group. If 208 is its true value, it should be excluded from the first two groups. All these arrangements are, for the present, only tentative, but I think that an increase in accuracy of determination will be more likely to increase than to diminish the number of indications of this kind.

My anticipation of a "ponderable disturbance of equilibrium, which must give rise to ætherеal oscillations in every chemical action," was published in 1864*. The confirmations of that anticipation, by Cooke, Mendelejeff, Meyer and others, lead me to hope that a careful consideration of the common factors in different supposed elements will help towards further analysis and, perhaps, towards the final discovery of the laws by which all chemical substances are developed from a single primitive form of matter.

55. *A Natural Thermal Unit.*

Any expression for the mechanical equivalent of heat which introduces the degrees of a thermometer-scale, must have an arbitrary character which may interfere with the ready conversion of thermal into other dynamic measurements. Moreover, it may well be questioned whether the mass-factor should be chosen, rather than the velocity-factor of *vis viva*, as a unit of comparison. If we consider force as a representative of matter in motion, different kinds of force would seem to be fitly characterized by differences of velocity rather than by differences of mass.

There is an obvious propriety in taking water as a representative medium, but there is no more need of considering a pound, or a kilogram, or any other definite quantity, in ordinary thermodynamic investigations, than there is in chemical researches. The three changes of state through which water passes, represent different well-defined amounts of work. The changes from gas to vapor and from liquid to solid do not involve any essential change of form, but the change from vapor to liquid converts an indefinitely expansible and compressible substance into one which is but slightly expansible and almost incompressible. It thus furnishes a natural thermal unit (v_k), which is a bond between tendencies to aggregation and to dissociation and a convenient standard for comparison between the equal actions and reactions of various forms of energy.

An atom or quantity x of water, in passing from the fusing to the boiling temperature, absorbs an energy sufficient to lift itself 772×180 feet, or 423.54×100 metres. This represents a wave- or projectile-velocity $v_k = \sqrt{2gh} = 2986.3$ feet $= .56558$ miles $= .9102$ kilometres per second.

56. *Weighing the Sun by the Thermometer.*

In two wave-systems, which are due, either directly or indirectly, to synchronous actions and reactions between two different masses, the wave-velocities are proportioned to the producing masses; for $v_k \propto gt \propto \frac{\mu t}{r^2} \propto \mu$. We have already found (Note 47) that the wave-velocity of solar

*Proc. Amer. Phil. Soc., ix, 439.

reaction against æthereal action ($G_0 T_0$) is the velocity of light (v_λ). Therefore, if v_λ and v_k are primitively synchronous, designating Earth's semi-axis major by ρ_3,

$$\text{Sun's mass } (\mu_0) : \text{Earth's mass } (\mu_3) :: v_\lambda : v_k :: \frac{\rho_3}{497.827} : .56538 \text{ miles} \ldots (1)$$

If we designate Sun's and Earth's densities, respectively, by δ_0 and δ_3,

$$\mu_0 : \mu_3 :: \left(\frac{\rho_3}{214.45}\right)^3 \delta_0 : r_3^3 \delta_3 \ldots\ldots\ldots\ldots (2)$$

$$\delta_3 : \delta_0 :: \left(2\pi\sqrt{\frac{r_0}{g_0}}\right)^2 : \left(2\pi\sqrt{\frac{r_3}{g_3}}\right)^2 :: (10049)^2 : (5078.6)^2 :: 1 : .2549 \ldots (3)$$

Substituting (3) in (2) we find, by elimination between (1) and (2),

$$\mu_0 = 328{,}424\ \mu_3.$$
$$\rho_3 = 92{,}472{,}100 \text{ miles}.$$
$$r_0 = \rho_3 \div 214.45 = 431{,}206 \text{ miles}.$$

57. *Convertibility of Natural Units.*

Stoney's notation, with the modifications proposed in Note 47, connects the electric and photic units through the equation:

$$v_0 = \mathrm{L}_0 \div \mathrm{T}_0 = \mathrm{l} \div \mathrm{t} = \mathrm{e} \div \mathrm{E} = (\mathrm{C} \div \mathrm{c})^{\frac{1}{2}} = (\mathrm{r} \div \mathrm{R})^{\frac{1}{2}}.$$

The gravitating, photic, thermal and electric units are, therefore, interconvertible by the equation

$$G_0 T_0 = v_\lambda = \frac{\mu_0}{\mu_3} v_k = v_0 = 185{,}751.6 \text{ miles} = 298{,}930 \text{ kilometres}.$$

It seems probable, in view of the mean result of my other physical investigations, that the above values of μ_0 and ρ_3 may be, respectively, about one per cent., and $\frac{1}{3}$ of one per cent., too small. If the calorie and J were estimated at the equator, the approximation would probably be still closer and, perhaps, exact.

58. *Solar Temperature.*

The infinitely projectile or radiating power of a central mass varies as $\sqrt{2gr} \propto \sqrt{\frac{\mu}{r}}$. When the comparison of mutual solar and terrestrial actions and reactions is made through their common radius or semi-axis major, $\sqrt{\frac{\mu}{r}} \propto \sqrt{\mu} \propto \sqrt{\frac{v_\lambda}{v_k}}$. As v_k is the thermal equivalent-velocity at Earth's surface for 100° C., we may infer that the mean radiating temperature, at Sun's surface, is $g_3 \times 100° \times \sqrt{328{,}424} = 27.739 \times 573.08° = 15895.90°$ C. The temperature deduced from Sun's semi-diameter (r_0) is $\frac{r_0}{1389.6 \text{ ft.}} = 16384.30°$ C., being 1.0307 times the value which is indicated by the mutual actions and reactions of solar and terrestrial mass. This approxi-

mation would be very satisfactory, even without attempting to account for the discrepancy. It is of the same order of magnitude as the orbital projections of the planets, and it represents, very closely, the *vis viva* of Jupiter's secular apsidal oscillation. For the ordinary thermal equivalent varies as the square of the corresponding velocity, or as the fourth power of orbital velocity. The fourth power of 1.0307 is 1.1287; Jupiter's secular *vis viva* of projection, according to Stockwell,* is $\frac{1.06083}{.93917} = 1.1296$.

59. *Permanency of Standards.*

The three controlling masses, at the nebulous centre, the nucleal centre, and the centre of condensation, exert a combined thermodynamic influence which may lend interest to a closer examination of the several interconvertible standards (Note 57). It is noteworthy, at the outset, that they are all maxima; G_0 representing the greatest gravitating energy in the solar system; T_0, the cyclical time of maximum disturbance of the centripetal tendencies of G_0; $v_\lambda = v_e$, the greatest known velocity of wave-propagation; μ_0, the greatest mass in the solar system; μ_3, the mass which exercises the greatest local influence upon the physical phenomena which are susceptible of the most minute observation; v_k, the greatest thermal range between the centripetal and centrifugal forms of the most widely diffused and most important body which is well known in the three states of solid, liquid and gas; $L_0 = G_0 T_0^2$, the sum of the accelerations of G_0 during T_0. The law of conservation of areas, as well as the law of constancy, requires that G_0 should vary inversely as T_0, in all stages of solar nebular condensation. The photic unit, v_λ, on account of the abundant evidence of its universal activity, as well as on account of the laws of equal action and reaction, and of the inverse variability of elasticity and density in homogeneous media, is presumably invariable. The thermal unit, v_k, is practically constant, but its dependence upon relations of mass which may be subject to slight, though inappreciable, variations, subordinates it to the photic unit. The electric unit, v_e, being identical with the photic unit, the question arises, which of the two should be regarded as primary, and which as secondary. Do not the facts that light is universal, while the various electrical units represent local relations, indicate the proper answer?

60. *Heat and Electricity.*

The probability of arriving at the unity of force through the study of æthereal oscillations, was indicated by me in 1864.† The special relations of electricity to heat, which Edlund subsequently discussed with great ability and fullness, are shown by the proportions,

$$\left(\frac{I}{i} = \frac{e}{E} = \sqrt{\frac{C}{c}} = \sqrt{\frac{r}{R}} = \frac{L_0}{T_0}\right) : v_k :: \mu_0 : \mu_3.$$

$$C : c\,v_k^2 :: r : R\,v_k^2 :: \mu_0^2 : \mu_3^2.$$

* Smithsonian Contributions, 232, p. 38.

† Proc. Am. Phil. Soc., ix, 356-60.

61. *Photo-thermal Unit.*

Since temperature varies as the square of the velocity, we have,

$$v_k^2 \; : \; v_\lambda^2 \; : : 100^\circ : \; x.$$
$$.56558^2 : 185{,}751.6^2 : : 100^\circ : 10786240000000^\circ.$$

The corresponding projectile abscissa may be found, in terms of Sun's semi-diameter, by multiplying by 1389.6 and dividing by r_0, (Note 56); $1389.6 \times 10{,}786{,}240{,}000{,}000 \div (431{,}206 \times 5280) = 6583265$; log. 6583265 $= 6.8184413$. This agrees, within less than $\frac{1}{7}$ of one per cent., with the photodynamic determination of the third centripetal abscissa in the stellar-solar paraboloid, (log. $A_{37} = 6.8190131$, Note 46).

62. *Thermo-gravic Paraboloid.*

By taking $\frac{1}{8} r_0$, $\frac{4}{9}$ L, and A_{37} as the paraboloidal elements, we substitute the thermal for the photic aspect of the æthereal waves and are enabled to compare gravitating actions with thermal reactions. We thus find,

$$\text{Log. } \eta = -.001788316$$
$$\text{Log. } \zeta = .0055973414$$

The closeness of agreement between the photic and thermal abscissas is shown by the following comparisons :

		Locus.	Photic.	Thermal.	Difference.
A_{21}	$\frac{1}{2}$	Mercury,	1.6527576	1.6527216	.0084 of 1 per cent.
A_{29}	$\frac{7}{8}$	Neptune,	3.8776006	3.8773517	.0578 " "
A_{39}	α	*Centauri,*	7.6663303	7.6656606	.156 " "

The greatest difference is, therefore, less than $\frac{1}{6}$ of one per cent. The photo-thermal unit (A_{38} = L M, see Note 46), is intermediate between the photo-gravic unit (A_{37}), and the stellar locus (A_{39}). We have thus five elementary loci where only three are required. By equations of condition we ought to be able to determine all the values which are involved, with much greater accuracy than will ever be possible by astronomical observations.

63. *Unity of Force.*

The belief that all forms of force are modifications of one fundamental energy, is as old as the oldest Greek philosophy, but no approximation towards a demonstration of the belief seems to have been made until Rumford performed his experiments at Munich, in 1798. During the present century, the undulatory theory of light has commanded a general acceptance, the science of thermodynamics has been largely developed, and Tyndall's works have made the reading world familiar with the proofs that heat is a mode of motion. Stephenson taught that the energies of sunlight were stored in vegetable growths and in coal-beds; Herschel called attention to the enormous elasticity of luminiferous æther and to the Sun's rays as "the ultimate source of almost every motion which takes place on the surface of the earth ;" Titius, Bode, Alexander and Kirkwood, presented evidences of law in planetary arrangement ; Peirce and Hill found similar

evidences in times of planetary revolution; Faraday strove in vain to reconcile the law of gravitation with the theory of conservation of energy; Weber and Kohlrausch introduced a general kinetic notation and found the importance of the velocity of light in electrical phenomena; Faraday discovered the magnetic influence upon light and Sir William Thomson stated that "the explanation of all phenomena of electromagnetic attraction or repulsion, and of electromagnetic induction is to be looked for simply in the inertia and pressure of the matter of which the motions constitute heat;" Maxwell* considered magnetic force as the effect of the centrifugal force of vortices, electromagnetic induction as the effect of the forces called into play when the velocity of the vortices is changing, electromotive force as arising from the stress on the connecting mechanism, and electric displacement as arising from the elastic yielding of the connecting mechanism.

64. *Reclamation.*

In 1863, I began a systematic series of investigations, in the hope of *verifying, by numerical measurements*, some of the supposed consequences which seemed to flow from the foregoing researches and hypotheses, and of *finding new clues* to the values and relations of the fundamental elements of physical energy. The division of forces into attractive and repulsive, as well as the equality of action and reaction led me to the study of the laws of elasticity and their influence on undulatory and cyclical motions. In my first paper† I called attention to the effects of cyclically alternating acceleration and retardation during rotation or revolution. In the course of the seven following months, I pointed out various relations which seemed to have been previously unnoticed, between heat, gravitation, electricity and magnetism, showing that many of the phenomena could be imitated and explained by the mechanical propagation of vibrations. The tendencies to equilibrium between gravitating pressure and æthereal elasticity, the necessary production of continual oscillations by opposing forces, the possibility of accounting for gravitation, electricity and magnetism by such oscillations moving with the rapidity of light, were all discussed during this period.

65. *Musical Rhythm.*

Fourier (Note 33) seems to have first given a mathematical demonstration of the *necessity* that cyclical motions should be also rhythmical. If the luminiferous æther is anything more than a hypothesis, which helps to explain an indefinite variety of phenomena, the tendency to the production of harmonic nodes in elastic media must greatly multiply the rhythmical manifestations, both cosmical and molecular. Some of those harmonies have long been known, their discovery having been apparently the result of accident, or of a happy guess. The number which will hereafter be made known will depend, in large measure, on the skill with which

* Electricity and Magnetism, ii, 417.
† Proc. Am. Phil. Soc., ix, 285, Dec. 1863.

lines of investigation are guided by an understanding of the influences and consequences of elastic action and reaction.

66. *Mass, Distance and Time.*

Laplace regarded force as proportional to velocity, treating momentum, or the product of mass by velocity, as the result of force acting on mass. He defined velocity as "the ratio of the space to the time employed in describing it." More recent writers consider force as equivalent to *vis viva*, involving both matter and motion, and represented by one-half the product of mass by the square of velocity, $\frac{mv^2}{2}$. Often, however, they follow Laplace in treating velocity as a ratio, designating distance or length by l, and time by t. The symbols m, l, t, therefore, are applicable in all discussions of force, and their use has paved the way for a ready acceptance of any evidence which may be adduced respecting the substantial unity of force. The fluctuating and arbitary values which have been assigned to the symbols, and the lack of any universally recognized standards of measurement, have obstructed the discovery of evidence without weakening the belief in kinetic unity. Even the recognition of a common velocity, in light and electricity, seems to have led to no systematic search for common standards of length and time.

67. *Maxima, Minima and Means.*

In all ordinary investigations, in any special department of dynamics, we deal with observed values which have a limited range, with a view of finding the most probable mean. In the study of forces which vary in accordance with known or supposed law, minimum or vanishing values claim special consideration. For a full understanding of any force we must also know the greatest energy of which it is capable, or of which we can obtain any practical experience. If we wish to compare different kinds of force, in order to ascertain the character of supreme and controlling energy, it seems especially important that we should turn our attention, at the outset, to the greatest manifestations of each of the elements of energy, m, l, t.

68. *Light and Electricity.*

For a long time, little was known of electricity except the phenomena of attraction, repulsion, and luminous manifestation. Faraday's want of success in searching for some bond of union between electricity and gravitation, deterred others from continuing the search. The undulatory theory of light enabled Weber and Kohlrausch to make their first determination of a velocity, which serves to connect many electrostatic and electromagnetic phenomena, and which is of the same order of magnitude as the velocity of light, v_λ. Their subsequent investigations, together with those of Thomson, Maxwell, Ayrton and Perry, showed that the two velocities are not only of the same order of magnitude, but that they are

probably identical, so that light and electricity may be properly regarded as different modifications of a more fundamental energy. Their common velocity is the greatest known velocity of wave-propagation, and we are thus further encouraged to the study of maxima as indications of kinetic unity. The elements l, t, and m are still arbitrarily assumed in electrical treatises, notwithstanding the suggestiveness of the well-known equation of wave-velocity, $v = \sqrt{2\,gh}$.

69. *Electrostatic and Electromagnetic Dimensions.*

Although arbitrary values have been assigned to m, l and t, in electrical discussion, the same values are generally assumed in electrostatic and electromagnetic comparisons. It has thus been found that the ratio between the two systems is the velocity of light for quantity of electricity, electric current, magnetic potential, electric displacement, surface density, magnetic force, strength of current at a point, quantity of magnetism, electrokinetic momentum of a circuit, line-integral of electromotive force, magnetic induction, electromotive force at a point, and vector potential. The ratio is the square of the velocity for electrostatic or electromagnetic capacity, dielectric or magnetic inductive capacity, conductivity and resistance. The product of these two ratios by mass, furnishes indications of momentum and *vis viva* which will doubtless be useful in many general kinetic comparisons.

70. *Heat and Gravitation.*

The direct opposition of tendencies in heat and gravitation, the former being centrifugal and the latter centripetal, leads to an easier and more direct means of comparison between the two energies than has been found in the case of light and electricity. But the adoption of mh or $\frac{ml}{2}$, as the mechanical equivalent of heat, leaves the relation of gravitation out of view, and it is not readily seen until we find that $mh = \frac{2\,m}{g} \times \left(\frac{h}{t}\right)^2$. Even then, the foot-pound and second, or the kilogrammetre and second, are such arbitrary values that there is no indication of any uniform standard like the velocity of light. We see, on further examination, that our knowledge of heat is wholly derived from phenomena at the Earth's surface, where terrestrial gravitation is a maximum, and we are thus led to accept Earth's mass as a fitting natural unit of mass in thermodynamic questions, especially in all questions which involve the factor $\frac{2\,m}{g}$. In order to reach kinetic unity, some values should be found for l and t which can be presented under some simple relation to the velocity of light.

71. *Central Energy of the System.*

We are now somewhat prepared to appreciate the reasoning of Herschel and Stephenson, in referring all terrestrial energies to the Sun, and to ac-

cept M_0 and G_0, or Sun's mass and superficial gravitation, as standards of comparison between Sun's centripetal and centrifugal, or gravitating and radiating energies. The Sun itself is subject to the paramount control of universal mass and gravitation. Although we have no means of finding their absolute or relative value, we may symbolize them by M_u and G_u and thus seek for standard values of L_0 and T_0. Every particle of the Sun is continually solicited by G_0 and G_u, and their varying solicitations can be compensated only by cyclical alternations of rise and fall, from and towards the universal centre of gravitation, c_u. In order that Sun's mass may be stable, the sum of the tendencies of G_0 must be equal to the sum of the tendencies of G_u, during each half-rotation. A solar half-rotation, therefore, may be taken as a natural standard value for T_0; then the equation $M_0 H_0 = \frac{2 M_0}{G_0} \times \left(\frac{H_0}{T_0}\right)^2$ gives $H_0 = \frac{G_0 T_0^2}{2}$, and $L_0 = 2 H_0 = G_0 T_0^2$ as a corresponding natural standard of length and distance.

72. *Standard Kinetic Modulus.*

If we examine the equation which we have found in the foregoing note for the natural unit of length, we find that H_0 represents the height of virtual fall which would give a velocity equivalent to $G_0 T_0$, and L_0 is the height of a homogeneous elastic atmosphere which would have a velocity of wave-propagation equivalent to $\frac{L_0}{T_0} = G_0 T_0 = G_u T_0$, the actions and reactions of G_0 and G_u being equal. But the elastic atmosphere, in which these actions and reactions take place, is the universal æthereal medium, and its velocity of wave-propagation, $\frac{L_0}{T_0}$, is the velocity of light. The relations of heat, mass and gravitation, therefore, lead us to the same fundamental velocity as the relations of the electrostatic and electromagnetic systems, and the same velocity as the solar radiations which are variously modified so as to produce the phenomena of light, heat, electricity, magnetism and actinism. Our knowledge of the significance of the electrical unit is thus extended, so as not only to include the ratio $\frac{L_0}{T_0}$, but also to show that the natural standard units of mass, length, and time are, respectively, M_0 = Sun's mass; L_0 = standard kinetic modulus, or Solar modulus of light; T_0 = half-time of solar rotation, or time of cyclical equality of action and reaction between solar inertia and æthereal undulation.

73. *Variable Units.*

In comparing arbitrary and variable units with the maximum standards, we have generally to deal with fractional values. In uniform velocities, like those of light, electricity, and primitive kinetic radiation, $l \propto t$; in variable velocities which are due to centripetal or centrifugal radiation, like those of gravitation and heat, $l \propto t^2$. Maxwell* gives electric di-

*Op. cit., ii, § 620-9.

mensions and formulas which can be readily converted into standard kinetic units ; gravitating formulas can be similarly converted through the correlations, $g \propto \frac{m}{l^2} \propto \frac{l}{t^2}$, $\sqrt{gr} \propto \left(\frac{m}{l}\right)^{\frac{1}{2}}$; thermal formulas, through the correlations, $w \propto [m]\, h \propto [m]\, v^2 \propto [m]\, \frac{l^2}{t^2}$.

74. *Complex Variability.*

Any variable unit may be dependent upon some other variable unit, and different values of m, l and t may thus be involved in the same expression. It is necessary, therefore, that the significance of every variable symbol should be fully understood before undertaking to convert it into terms of the corresponding standard unit. For example, in the thermal and electric formulas, $[m]$ refers to the mass which is lifted against the constant pull of gravity, while in thermal formulas v, l and t also introduce considerations which are dependent upon the centripetal energy of Earth's mass, m_3, at a constant distance. The conversion of thermal into standard formulas, therefore, requires due attention to the ratios both of $[m]$ and m_3, to M_0. In such cases it may often be well to introduce a second natural unit, which can be simply derived from the standard unit, as in the deduction (Note 56) of the terrestrial thermal unit of velocity from the solar unit of luminous velocity, $v_k = \frac{m_3}{M_0} V_0 = m_3 M_0^{-1} L_0 T_0^{-1}$.

75. *Notation and Approximate Values.*

Let r_a = Sun's apparent semi-diameter $\doteq$* 961.″83........2.9830990

$n = r + r_a \doteq 214.45$..............................2.3313261

r_0 = Sun's semi-diameter $\doteq$ 431,208 miles.............5.6346866

$\rho_3 = nr_0$ = Earth's semi-axis major $\doteq$ 92,472,500 miles..7.9660127

r_3 = Earth's semi-diameter $\doteq$ 3962.8 miles............3.5980023

p_0 = Sun's parallax $= \frac{r_3\, r_a}{r_0} \doteq$ 8.″8392................ .9464146

$t_0 = 2\pi\, (r_0\, G_0^{-1})^{\frac{1}{2}}$ = 1 year + $n^{\frac{3}{2}} \doteq$ 10049 seconds...4.0021233

$t_3 = 2\pi\, (r_3\, g_3^{-1})^{\frac{1}{2}} \doteq 5073^s.6$.........................3.7053158

d_0, d_3 = density of Sun, Earth.......................

$\frac{d_0}{d_3} = \left(\frac{t_3}{t_0}\right)^2 \doteq$ .25491..............................$\bar{1}$.4063870

l_0 = Laplace's limit $= n\left(\frac{2}{1}\frac{T_0}{\text{yr.}}\right)^{\frac{2}{3}} \doteq 36.3658\, r_0$........1.5606934

$V_0 = \frac{L_0}{T_0} = \rho_3 + 497.827 \doteq .4307721\, r_0$ = velocity of light. $\bar{1}$.6342476

$v_0 = 2\pi\, r_0 + t_0 \doteq .0006252556\, r_0$.....................$\bar{4}$.7960576

$v_k = (2\, g_3 \times 180\, J + 1\, \text{lb.})^{\frac{1}{2}} \doteq$ .56558 miles..........$\bar{1}$.7524940

*Nearly equal. The right hand column contains the approximate logarithms.

$g_3 = 32.088$ ft. $\doteq .0060773$ miles........................$\bar{3}.7837087$
$G_0 = v_0^2 \div r_0 \doteq .0000003909446\, r_0$......................$\bar{7}.5921152$
$T_0 = V_0 \div G_0 \doteq 1101875$ seconds......................6.0421324
$L_0 = V_0 T_0 = (V_0 \div v_0)^2\, r_0 \doteq 474657\, r_0$................5.6763800
$M_0 = V_0 \div v_k = r_0^3\, d_0 \div r_3^3\, d_3 \doteq 328438\, m_3$............5.5164402

Substituting the value of r_0 we find,

$l_0 \doteq 15,681,230$ miles................................ 7.1953800
$V_0 \doteq 185,752$ miles................................. 5.2689342
$v_0 \doteq 269.615$ miles 2.4307442
$G_0 \doteq 890.1$ ft. $\doteq .16858$ miles......................... $\bar{1}.2268018$
$L_0 \doteq 2213.37\rho_3 \doteq 73.67$ Neptune's semi-axis major $\doteq$
204,675,900,000 miles........................11.3110666

76. *Vis viva of Wave Propagation.*

In 1857, Professor Stephen Alexander announced to the American Association the approximate equality of md^2 in the two planets, Jupiter and Saturn, which make more than $\frac{1}{1}\frac{4}{5}$ of the aggregate planetary mass in our system. He also showed that the mean distance of Saturn is nearly equivalent to $\frac{8}{5}$ of Jupiter's mean distance, and that the ratio $\frac{8}{5}$ has been largely influential in planetary distribution. In 1872, I showed* that the same ratio may be deduced from the thermal energy of chemical combination, representing the ratio of mean *vis viva*† of oscillating particles to *vis viva* of wave propagation. In 1877, Maxwell and Preston‡ published the same ratio, without seeming to have known that I had already deduced it from the laws of kinetic oscillation in elastic media. Its importance in discussions of kinetic unity, is evident from the fact that it is alike operative in the establishment of cosmical§ and of molecular harmonies.

77. *Conical Pendulums.*

The tendencies to concentration, through the mutual attractions of particles which are subjected to a simultaneous linear projection, and other combinations of tendencies to uniform and to variable velocities, lead to many oscillations which follow the laws of conical pendulums. It is therefore important, in investigations which involve cyclical elastic action, to inquire what forms of pendulum-vibration will best fulfil the requirements of Fourier's theorem. The general formula for the velocity of a conical pendulum is,

$$v = \sqrt{gr \sin\theta \tan\theta}.$$

Hence, since $t = 2\pi r \sin\theta \div v$, we find

$$t = 2\pi \sqrt{\frac{r}{g}\tan\theta}.$$

* Proc. Am. Phil. Soc., xii, 392–4.
† Ib. foot note.
‡ P. Mag. [5], iii, 453; iv, 209.
§ Proc. A. P. S., xii, 403–5, *et seq.*

This is equivalent to twice the time of vibration in a simple pendulum of the same height, (cos θ), or to the time of vibration in a linear pendulum of four times the height. The requirements of *vis viva*, synchronism, and the conversion of wave-propagating velocity into velocity of oscillation under central action, are all satisfied, as I have shown in my discussions of explosive energy (Note 16, *et al.*), by combining the ratios of this and the foregoing note, $\frac{1}{4} \times \frac{5}{8}$.

78. *Standard Temperatures.*

In thermodynamic deductions and comparisons, it is often important to decide what temperature should be taken as the standard. Whenever a sufficient number of kinetic values have been deduced for the natural units, M_0, L_0, T_0, the introduction of conditioning equations may help us to much accurate and useful knowledge which will lead to greater precision in many details of molecular physics. The present range of uncertainty may be estimated by examining the influence of two different possible standards upon the results of Note 16. The combining calories appear to have been observed, in each instance, at the temperature of 15° C. To reduce the mean to 0°, we have

$$\begin{aligned} H_2 &= 2 \times 15 \times 3.409 &= 102.27 \\ O &= 16 \times 15 \times .2175 &= 52.20 \\ \hline &\text{Total deduction} &= 154.47 \end{aligned}$$

Leaving 68886 — 154.47 = 68731.53 calories

$$\frac{5}{8} \times \frac{1}{4} \times \frac{1}{6} \times 68731.53 \times \frac{1889.6}{5280} = 279.15 \text{ miles} = h_1.$$

On the other hand, if we take the mean between the freezing and boiling points, as in Note 75, we find

$68886 + \frac{7}{3}$ of $154.47 = 69246.43$ calories, representing $h_2 = 281.24$ miles.

h_1 gives $m_0 = 332,693\, m_1$; $nr = 92,871,000$ miles.
h_2 " $m_0 = 328,989\, m_1$; $nr = 92,525,000$ miles.
Note 75 $m_0 = 328,438\, m_1$; $nr = 92,472,500$ miles.

79. *Factors of Vis Viva.*

Although ordinary kinetic investigations involve considerations both of mass and velocity, the equality of action and reaction furnishes data, in many cases, for dispensing with one of the three kinetic units. For example, the equation of circular orbital revolution, $v = \sqrt{gr} = \sqrt{\frac{m}{r}}$, may be put in the form $\frac{l}{t} = \frac{\sqrt{l' l''}}{t} = \frac{\sqrt{rd}}{t}$, and we may use either of the equivalent values without vitiating our results. The meaning of the mass-factor is especially obscure in the "dimensions of electric units," but when we see that m is regarded as the product of electrostatic $m^{\frac{1}{2}}$ by electromagnetic $m^{\frac{1}{2}}$, and when we remember the importance of Ampere's

theory of currents, we are reminded of the orbital equations, and if we still think of mass, it is only because we have learned to regard mass as a necessary element of force. If we look still further, and see that the product of two masses must be considered in order to secure strict accuracy in the determination of orbits, we can find no good meaning for the square root of a mass. But if electric phenomena are simply the result of oscillations in the luminiferous æther, which represent the actions and reactions of inertia and elasticity, we may reasonably look for analogous phenomena in cosmical arrangements.

80. *Cosmical Illustration.*

In the mutual actions and reactions of two masses, $v = \sqrt{gr} \propto \sqrt{\frac{m}{r}} \propto \sqrt{m}$;* $v^2 \propto m$; $\frac{m}{v} \propto v$. Let m_0, m_3, m_5 designate Sun, Earth, Jupiter; v_3, Earth's aphelion velocity; v_λ, velocity of light. Then we find

$$\frac{m_0}{v_\lambda} : \frac{m_3}{v_3} :: \frac{m_3}{v_3} : \frac{m_5}{v_\lambda}$$

For, $v_\lambda = \rho_3 \div 497.827$; $v_3 = 2\pi\rho_3 \div 1.01677 \div 31558149$; $m_0 = 1047.879\, m_5$. Substituting these values, we find: $m_5 = 316.9\, m_3$; $m_0 = 332{,}072\, m_3$; $\rho_3 = 92{,}559{,}700$ miles. Hence we see that the reaction of Earth against the forces which produce its orbital velocity, at the moment when it is least affected by Sun, is a mean proportional between the reactions of Sun and Jupiter against the velocity of light. In other words, the reaction of inertia at the centre of density (Earth) against the inertia at the centre of nebulosity (Jupiter) and at the centre of nucleation (Sun) is limited in each direction by the reactions of controlling inertia against æthereal elasticity.

Multiplying the terms of the above proportion by $v_\lambda^2\, v_3$, we have

$$m_0 v_\lambda v_3 : m_3 v_\lambda^2 :: m_3 v_\lambda^2 : m_5 v_\lambda v_3.$$

The importance of the reactionary *vis viva* at the centre of condensation is thus shown, and the *vis viva* at the coördinate centres represents a mean proportional between the æthereal and the central orbital *vis viva*.

81. *Mutual Convertibility of Gravity and Magnetism.*

In the first set of electrostatic, magnetic and electrokinetic pairs, the product of the two dimensions represents an energy, or *vis viva*. Maxwell† gives the following equations:

$$[e\,E] = [m\,\Omega] = [p\,C] = \left[\frac{L^2 M}{T^2}\right].$$

The symbols denote, respectively, the products of quantity of electricity by electric potential, quantity of free magnetism by magnetic potential,

* Because r represents the distance between the two masses and does not affect the ratio.

† Elec. and Mag., ii, 240.

electrokinetic momentum of a circuit by electric current, mass by the square of the velocity of light. *The last product is, therefore, precisely the same as* $m_3 v_\lambda^2$, *in the foregoing note,* and it furnishes further grounds for considering the primitive oscillations as luminous, rather than electric. There are as good reasons for assuming Earth's mass as the fundamental electric value of M, as for assuming the velocity of light as the corresponding value of $\frac{L}{T}$, and this assumption brings electric and thermal phenomena into simpler and more intelligible relations. The anticipations of my first paper* upon the relations of electricity and magnetism to gravitation are thus very fully and satisfactorily confirmed.

82. *Chemical Units.*

The influence of electric and thermodynamic laws on chemical phenomena has long been recognized. There are two special applications of electric dimension to which I would call attention, on account of their apparent bearing upon spectral harmonies and combining equivalents.

I. The second set of electrostatic, magnetic and electrokinetic pairs gives the following equations :

$$[\mathfrak{D}\,\mathfrak{E}] = [\mathfrak{B}\,\mathfrak{H}] = [\mathfrak{C}\,\mathfrak{A}] = \left[\frac{M}{L\,T^2}\right].$$

The symbols denote, respectively, the products of electric displacement by electromotive force at a point, magnetic induction by magnetic force, intensity of electric current at a point by vector potential of electric currents, and the dimensions of energy referred to unit of volume. The last member of the equation also represents the unit of density, or atomic weight of an element, and thus opens a wide field for investigation, both in chemical and in general physics.

II. Weber found, by experiment, that the unit of electro-chemical force is to that of electromagnetic force as $106\frac{2}{3}$ is to 1. Designating the electro-chemical unit by χ and the electromagnetic unit by μ, if we suppose them to vary inversely as the squares of the reacting velocities (Note 80), we find

$$\left(\frac{m_0}{v_\lambda}\right)^2 : \left(\pi\frac{m_3}{v_3}\right)^2 :: \chi : \mu :: 106.17 : 1.$$

This differs from Weber's experimental value by less than $\frac{1}{2}$ of one per cent. The π-factor designates the ratio between the time of acquiring atmospheric orbital velocity at Laplace's limit, t_a, and the time of acquiring nucleal dissociative velocity, t_n;

$$t_a : t_n :: 1 : \pi.$$

83. *Positive and Negative.*

The oppositions of solar and Jovian photodynamic reaction, which are shown in the first proportion of No. 80, may perhaps help towards a better

* Proc. Am. Phil. Soc., ix., 355–60; April 1, 1864.

understanding of the difference between positive and negative electricity, or austral and boreal magnetism. While the action of æthereal oscillations must be modified by every centre of inertia, whether cosmical or molecular, the reactions of Sun and Jupiter must always greatly preponderate. In analyzing the product of the reactions into electrostatic and electromagnetic elements, $M^{\frac{1}{2}}$ may be considered as representing a mean proportional between the positive and negative masses. Reasoning from analogy, it seems probable that the electric M may represent a product, and $M^{\frac{1}{2}}$ a mean proportional, in all cases.

84. *Sun-Spots and Planets.*

The evidences of connection between sun-spots and planetary perturbations, the phyllotactic rhythm in periods of planetary revolution which was pointed out by Peirce and Hill,* the twelve harmonic nodes between Mercury and Sun of which I have already given evidence,† the relations of "magnetic storms" to sun-spots and to auroras, the confirmation of my first intra-Mercurial node by the British sun-spot observations,‡ as well as the various indications of a possibility that Swift's and Watson's planets may have been transient nodal aggregations, all seem deserving of consideration in studying the actions and reactions among the various forms of kinetic energy.

85. *Stellar relations of Central Density.*

In the stellar-solar paraboloid the abscissa which indicates Earth's nebula-rupturing locus, is also the locus of solar-rupture in subsidence-collision. The multiples 3, 4, 5, appear as coefficients, either of incipient subsidence or of final rupture or of both, for Earth, Mars, mean asteroid and Jupiter. their rupturing loci being, respectively, $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$, $\frac{5}{6}$ of their semi-axes major. The corroboration of the importance of Earth's position at the centre of density, which is furnished by Note 80 *et seq.*, is strengthened by the following multiple relations of Earth's semi-diameter, r_3:

1	$(3 \times 4 \times 5) \times r_3 \doteq$	Moon's semi-axis major.
2	$(3 \times 4 \times 5)^2 \times r_3 \doteq$	Perigee of Venus.
3	$(3 \times 4 \times 5)^3 \times r_3 \doteq$	Saturn's semi-axis major.
4	$4\,(3 \times 4 \times 5)^4 \times r_3 \doteq$	Solar modulus of light.
5	$.2\pi\,(3 \times 4 \times 5)^5 \times r_3 \doteq$	Distance of *α Centauri*.

The deviations are of the same order of magnitude as planetary eccentricities, being as follows: 1, about $\frac{1}{2}$ of one per cent.; 2, nearly $2\frac{3}{8}$ per cent.; 3, nearly 3.4 per cent.; 4, less than $\frac{1}{24}$ of one per cent.; 5, less than $3\frac{2}{3}$ per cent. The fourth locus is equivalent to the *latus rectum* of a paraboloid in which modulus is the focal abscissa; the fifth is $\frac{\pi}{2}$ of (3 × 4 × 5

* Proc. Amer. Assoc., v, 2.

† Proc. Am. Phil. Soc., xix, 367.

‡ Ib., xiii, 470.

$\times$ the fourth, $\frac{\pi}{2}$ being the ratio of circular-orbital velocity to mean velocity of synchronous radial oscillation.

86. *Prime Centres of Energy.*

In considering the photodynamic reactions of Sun against the æthereal oscillations, reference has been had to Sun's centre of gravity, C_0. In my first paper* on the influence of cyclical oscillation, I anticipated the possibility of measuring fluctuations which are produced by the Central Sun. The first step in that direction was the discovery of the stellar-solar paraboloid, by means of the rupturing tendencies which would result from Herschel's theory of "subsidence," in a nebulous elastic medium. The next step was the investigation of the relations of the solar centre of gravity to the universal centre of gravity, C_u, which are involved in the cyclical equilibrium of æthereal and gravitating energies. It is perhaps possible for mathematical analysis to find some approximation to the mass and distance of the controlling centre of the immediate stellar group to which we belong, from known data. In seeking such approximation, regard should evidently be paid to the motions of the centre of gravity of the solar system, C_a. The next centre in point of importance is, perhaps, the centre of condensation in the solar system, C_3.

87. *Projection of Centres of Nucleation, Nebulosity and Condensation.*

It may be assumed that the mean centre of gravity of our system, C_a, is the same as the mean centre of gravity of its two chief masses, Sun and Jupiter. Jupiter's semi-axis major, ρ_5, is equivalent to $5.202796\rho_3$. Sun's mass, m_0. is 1047.879 times Jupiter's mass, m_5. Sun's semi-axis major, ρ_a, or mean projection from C_a, is therefore $\frac{5.202796\rho_3}{1 + 1047.879}$, or $.0049603\rho_3$. Stockwell's estimate† of the secular maximum eccentricity of Jupiter is .060874, which represents a rupturing projection, for C_a, of $\frac{1}{1 - .060874}$ $= 1.0648r_0$. The equation, $.0049603\rho_3 = 1.0648r_0$, gives $\rho_3 = 214.667r_0$; $n = 214.667$. This is about $\frac{1}{10}$ of one per cent. greater than the estimate of the British Nautical Almanac, and about $\frac{1}{10}$ of one per cent. less than that of the American Nautical Almanac.

88. *Orbital and Nascent Energies at the Centre of Condensation.*

The evidences of photodynamic projection, which were presented in Note 80, together with other evidences of the importance of Earth's mass and semi-diameter, as secondary thermal and electric units, enable us to connect orbital velocity, v_a, with nascent or dissociative velocity, v_β, at the centre of condensation, Earth. For, since distance or *vis viva* of projec-

* Proc. Am. Phil. Soc., ix, 283.

† Smithsonian Contributions, 232, p. 38.

tion against uniform resistance varies as the square of the time of communicating or overcoming the velocity of projection, we find the proportion: Sun's projectile locus or semi-axis major, ρ_α, *is to* Earth's projectile locus or semi-axis major, ρ_β *as* the square of the time of communicating orbital velocity, t_α^2, *is to* thesquare of the time of communicating nascent or dissociative velocity, t_β^2. Assuming the values, $\rho_\alpha = 1.0648 r_0$, $\rho_\beta = 214.667 r_0$, in accordance with the foregoing note, and remembering that t_β is always the time of a half rotation, we have

$$1.0648 : 214.667 :: t_\alpha^2 : 43082^2$$
$$t_\alpha = 3034.25 \text{ sec.}$$
$$v_\alpha = 3034.25 \times 32.088 \div 5280 = 18.44 \text{ miles.}$$
$$\rho_3 = 18.44 \times 31558149 \div 2\pi = 92,617,300 \text{ miles.}$$

89. *Double Systems of Photodynamic Oscillation.*

In 1864, I suggested* "that one of the most probable results of the rotation of the earth with its atmosphere, in an æthereal medium, would be the production of two systems of oscillations, moving with the rapidity of light, one in the line of the Earth's orbit, and the other in the line of its radius vector, and that those systems would be constantly so related that while one tended to retard, the other would tend to accelerate the Earth's motion." In 1866, I showed† that "the velocity of light is nearly the same as the velocity which would be acquired in one year by a falling body, under the influence of an accelerating force equivalent to the force of gravitation at the Earth's surface." Although I regarded this approximation, at first, as "perhaps merely a curious accidental coincidence," it became so prolific in suggestive leadings that I was able to show its dependence upon simple dynamic laws of æthereal condensation. From the electrostatic analogies of condensation and the electrokinetic analogies of orbital motion, we may infer the probable applicability of the law of energy and stress of radiation, "that at every point of the wave the intrinsic energy of the medium is half electrostatic and half electrokinetic."‡ At the locus of primitive coincidence between orbital and rotary velocity, this division of energy would lengthen the time of acquiring the solar nascent dissociative velocity of light to a complete rotation of the centre of condensation, the time for the nucleus being a half-rotation. Dividing one year by the square root of the ratio of solar photodynamic projection (Note 88), we find 31558149 seconds $\div \sqrt{1.0648} = 3058254$ sec.; $v_\lambda = 3058254 g = 185,858$ miles; $\rho_3 = 497.827 v_\lambda = 92,525,300$ miles. This differs by less than one-tenth of one per cent. from the value given in the foregoing note.

* Proc. Am. Phil. Soc., ix, 408.

† Ib., x, 269.

‡ Maxwell, ii, 391.

90. *Formulas for Conversion of Energy.*

All forms of energy, mechanical, thermal, photic, electric, magnetic or chemical, are derived from and can be compared with the maximum energy, $\frac{M_0 L_0^2}{T_0^2}$.

α. All astronomical, barometric, or other mechanical estimates of solar mass and distance, involve the proportionality, $g \propto \frac{m}{r^2}$.

β. The arbitrary units of thermodynamics are based upon the work done against the centripetal accelerations of terrestrial gravity. The unit of acceleration at unit of distance, or the sum of accelerations in unit of time, is proportioned to mass. Therefore, if we designate Earth's mass by m_3, we have $M_0 : m_3 :: V_0 : u_3$.

V_0, or the velocity of light is, as we have seen, the velocity acquired during the cyclical actions and reactions of solar condensation and æthereal elasticity at Sun's surface; $u_3 = .56558$ miles, is the velocity acquired during the cyclical actions and reactions of water-congelation and evaporation at Earth's surface. Dividing by $\sqrt{180}$ for the Fahrenheit scale, or by $\sqrt{100}$ for the Centigrade scale, we have the arbitrary units of velocity, .042156 miles for 1° F., or .056558 miles for 1° C. The equation $v = \sqrt{2gh}$ gives $h = 772$ ft. for 1° F. or 1389.6 ft. $= 424$ meters for 1° C. Combining these heights with the arbitrary units of mass we have J $= 772$ ft. lb. for the English thermal unit, and C $= 424$ kilogrammetres for the calorie or French thermal unit.

γ. Thermal, mechanical and photodynamic energies may be compared with energies of chemical combination through the ratio

$$M_0 : m_3 :: V_0 : u_3 :: h_0 : h_7.$$

h_0 is Earth's mean distance from Sun, h_7 is $\frac{1}{4}$ of $\frac{8}{9}$ of the height to which water-vapor would be thrown, against the retardation of gravity, by the combining energy of H_2O (Note 16, etc.).

δ. Cosmical, electric and photodynamic energies may be compared by means of the ratio

$$M_0 V_0 v_3 : m_3 V_0^2 :: m_5 V_0^2 : m_3 V_0 v_3.$$

Sun, M_0, is at the centre of nucleation in the solar system; Earth, m_3, at the centre of condensation; Jupiter, m_5, at the nebular centre; v_3, is Earth's aphelion or "nascent" orbital velocity.

ε. The electrostatic, magnetic and electrokinetic units of energy can all be derived from the above expression for Earth's photodynamic energy, $m_3 V_0^2 = \frac{m_3 L_0^2}{T_0^2}$, through the equations

$$[e E] = [m \Omega] = [p C] = \frac{M L_0^2}{T_0^2}$$

The bracketed symbols represent, respectively, quantity of electricity; line integral of electromotive force, or electric potential; quantity of free

magnetism, or strength of a pole; magnetic potential; electrokinetic momentum of a circuit; electric current.

ζ. Atomic energy, or energy of unit volume, can be compared with Earth's photodynamic energy of unit volume, $\frac{m_3 L_0^2}{r_3^3 T_0^2} = \frac{m_3}{L_1 T_0^2}$, and with corresponding electric energies, through the equations

$$[\mathfrak{D}\,\mathfrak{E}] = [\mathfrak{B}\,\mathfrak{H}] = [\mathfrak{C}\,\mathfrak{A}] = \frac{M}{L T^2}$$

The bracketed symbols represent, respectively, electric displacement (measured by surface-density); electromotive force at a point; magnetic induction; magnetic force; current electric intensity at a point; vector potential of electric current.

η. Electrochemical and electromagnetic energies may be compared with thermal, photodynamic and other energies, through the proportion

$$\chi \ : \ \mu \ :: \ M_0 t_a^2 \times M_0 v_3^2 \ : \ m_3 t_n^2 \times m_3 V_0^2$$

I designate Weber's units of electrochemical and electromagnetic force by χ and μ, respectively; t_a is the time of acquiring orbital velocity, or incipient associative energy, at Laplace's limit of equal velocities of rotation and revolution; t_n is the time of acquiring nucleal nascent or dissociative velocity.

$$t_a \ : \ t_n \ :: \ 1 \ : \ \pi$$

θ. Total magnetic force, φ_0, can be compared with the reactions of terrestrial magnetic force, φ_3, by the proportion

$$M_0^2 \ : \ \pi^4 m_3^2 \ :: \ \varphi_0 \ : \ \varphi_3$$

The reactions of orbital tendency are $t_a M_0^{\frac{1}{2}}$, $t_n m_3^{\frac{1}{2}}$, respectively; centripetal acceleration varying as the fourth power of orbital velocity, we have the ratio, $M_0^2 \ : \ \pi^4 m_3^2$.

(Contributions from the University of Pennsylvania, No. 16.)

On Alaskaite, a new member from the series of Bismuth Sulphosalts. By Professor George A. König.

(Read before the American Philosophical Society, June 17, 1881.)

Mode of occurrence. The high mountain mass of south-western Colorado culminates in Mt. Sneffels at an altitude of 14,156 feet. But this great height does not impress itself upon the observer since the deepest valleys are still 7000 feet above the sea. The geological structure of these mountains is very simple as a whole; but the energetic action of the forces of erosion, has produced a very rich and picturesquely carved topography, there being no table mountains, but only steep peaks and sharply indented crests. Mineral veins in clearly defined outcrops intersect these moun-

tains in astonishing abundance. They are easily traced on the bald slopes, which rise from one to three thousand feet above timber line. The geology, as already stated, is quite simple. Orthoclastic eruptive rocks—Quartz-porphyry, Porphyrite and Trachyte—overlie granitoid metamorphic schists (chiefly gneiss) as an enormous sheet one mile thick. Only towards the West we find palæozoic rocks, sandstones, limestone and coal beds, lying between the crystalline top and bottom rocks, not exceeding probably 500 feet in thickness. All the peaks and crests visited by me were found to be made up of porphyritic rocks, schists and sedimentary rock being only found in the deep cañons. The silver bearing veins I found to be confined to the eruptive rocks with but few exceptions, *i. e.*, the "mineral farm," near Ouray in Silurian limestone; the "black Wonder mine" and some other veins in Burough's Park, which lie in granitoid gneiss.

One of the most interesting sections of this wonderful region is *Poughkeepsie Gulch*, one of the head forks of the Uncompaghre river. Here we find numerous veins in a bleak wilderness directly under the pass which leads from the Uncompaghre valley over into the Cement creek, one of the feeders of the Animas river. Very prominent among its neighbors is the *Alaska* vein which was opened by two adits at the time of my visit last August. The vein is well defined, striking nearly north and south, with almost vertical dip. The breast of the lower adit showed beautiful ore. Nests of gray copper and Alaskaite in a gangue of quartz and barite. Even with candle light the gray copper and Alaskaite (Bismuth silver ore so called here) are distinguishable, and are separated by handpicking into first class, and second class ore. I found some difficulty in procuring specimens, as the foreman had orders not to allow specimens being taken away.

Physical properties of Alaskaite. The specimens consist of a more or less intimate mixture of the new mineral with barite and chalcopyrite, and sometimes a little quartz. Neither blende nor galenite could be detected. The small quantity of antimony shown by the analysis might be due to the presence in the mixture of some gray copper or other Stibiosulphosalts, or may be replacing bismuth in the Alaskaite. But could in no way interfere with the correct definition of the new mineral, as will be seen later. The complete decomposition with hydrochloric acid speaks quite in favor of the latter view.

The structure of Alaskaite is small foliated, some smooth cleavage planes may be observed here and there. Its color is whitish lead-gray, approaching bismuthinite; its lustre strongly metallic; opaque. Color of the fine powder is bluish-gray. The structure forbids a determination of hardness, but the mineral is mild in the mortar, and easily friable.

The *specific gravity* was determined with the fine powder used for the Analyses C and D, and found to be 6.878 by the following calculation:

Let $S = 1^{g}.3165 = A + B + C$ (Alaskaite + barite + chalcopyrite)

then we have $p = \frac{A}{\delta} = \frac{S-B-C}{\Delta-\delta_1-\delta_2}$

The analysis gives B = 0.15; S = 0.1975; C = 0.228; S = 0.0301

$\delta_1 = \frac{0.1975}{4.486} = 0.644$; $\delta_2 = \frac{0.0301}{4.2} = 0.0072$

$\Delta = 0.2095$ by experiment.

hence $S—B—C = A = 1.0889$; $\delta = \Delta—\delta_1—\delta_2 = 0.1583$

and $p = \frac{1.0889}{0.1583} = 6.878$.

Blowpipe reactions. The mineral decrepitates in the closed tube, similarly to the majority of compounds belonging to this group, it melts then at red heat without the formation of a sublimate. Heated with the O. Fl. on charcoal it yields a deep yellow incrustation with a white non volatile fringe, coloring the seam of the flame faintly azure blue (lead). Upon continued blowing a crimson to peach blossom red zone appears between the yellow and white incrustation (silver). The residue gives the reactions of copper and iron with borax and microcosmic salt, and after cupellation with lead, a considerable silver button. With potassium iodide and sulphur an intense brick red coating is obtained (bismuth). In the open tube sulphurous anhydrite (sulphur) and a minute white sublimate (antimony) are given off, while a yellow residue is produced. Cold concentrated hydrochloric acid acts very slowly upon the finely pulverized mineral, but the heated acid decomposes it completely and rapidly, leaving flocculent silver chloride.

Analyses. So intimate is the mixture of Alaskaite and chalcopyrite, that a complete mechanical separation was not feasible. Now it is quite possible to remove the Alaskaite by HCl from the chalcopyrite and barite, but the quantity of copper-iron-bisulfide is always so small (see analyses) that if the iron be taken as representing chalcopyrite, no appreciable error will be committed. A small quantity of the mineral was picked out carefully, leaving only traces of chalcopyrite, for a preliminary analysis. 250 mg. gave: $Bi_2O_3 = 160.0$ mgr; $PbSO_4 = 38.0$ mgr. $Ag\,Cl = 23.5$ mgr; $CuO = 7.0$ mgr; birite = 8.3 mgr. The substance minus barite was 141.7 mg. Calculated upon this number we have:

$Bi_2S_3 = 73.02$; $PbS = 12.40$; $Ag_2S = 9.06$; $Cu_2S = 6.20$ corresponding very closely to the ratio $(RS)_{20} + (Bi_2S_3)_{21}$ that is probably as 1 : 1. A quantitative blowpipe assay gave 7.5 p. c. Ag, or minus barite, 8.90 Ag_2S.

With less carefully picked material the following 2 analyses were made, A and B, the determinations of Bi and Pb in A being lost:

	A ($1^g.5000$)	B ($1^g.0000$)
Insoluble	0.2382	0.1551
AgCl	0.1337	0.0945
CuO	0.0710	0.0462
Fe_2O_3	0.0220	0.0168
ZnO	0.0040	0.0030
BiClO	——	0.4945
Bi_2O_3	——	0.0385
$PbSO_4$	——	0.1480
$BaSO_4$	——	0.9683

Deducting the insoluble (barite) we obtain per cent.

	A	B	Mean.
Bi =	——	51.49	51.49
Pb =	——	12.02	12.02
Ag =	7.97	8.19	8.08
Cu =	4.49	4.37	4.43
Fe =	1.22	1.40	1.31
Zn =	0.24	0.29	0.26
S =	——	17.20	17.20
			94.79

Deducting again Fe = 1.31 ; Cu = 1.43 ; S = 1.48 as chalcopyrite, we obtain for Alaskaite

Bi =	51.49 :	208 =	0.2475	
Pb =	12.02 :	207 =	0.0585	0.1236
Ag =	8.08 :	216 =	0.0374	
Cu =	3.00 :	126.4 =	0.0237	
Zn =	0.26 :	65 =	0.0040	
S =	15.72 :	32 =	0.4912	

that is 0.1236 R : 0.2475 Bi : 0.4912 S = 1 : 2.002 : 3.974

Notwithstanding the simple ratio, this result cannot be utilized to base definite conclusions thereon, since there is an unaccounted loss of nearly 5 per cent. in the analyses. From the same specimen material was now taken off another corner, and 2 analyses made as follows :

	C ($1^g.000$)	D ($1^g.0000$)	Mean.
Bi =	47.27	46.47	46.87
Sb =	0.51	——	0.51
Pb =	——	9.70	9.70
Ag =	7.19	7.01	7.10
Cu =	3.54	3.75	3.64
Fe =	0.70	0.70	0.70
Zn =	0.56	0.72	0.64
S =	15.85	——	15.85
Insoluble =	14.90	15.10	15.00
			100.01

Taking the iron again as coming from chalcopyrite we deduct 0.79 Cu and 0.79 S, leaving

Bi =	46.87 :	208 =	0.2253	0.2294
Sb =	0.51 :	122 =	0.0041	
Pb =	9.70 :	207.2 =	0.0468	0.1133
Ag =	7.19 :	216 =	0.0342	
Cu =	2.85 :	126.4 =	0.0225	
Zn =	0.64 :	65 =	0.0098	
S =	15.07 :	32 =	0.4709	0.4709
$(Fe_1Cu)S_2$ =	2.28			
Barite =	15.00			

hence R : Bi : S = 1 : 2.020 : 4.14

The composition of Alaskaite is therefore in 100 parts

Bi	=	56.97
Sb	=	0.62
Pb	=	11.79
Ag	=	8.74
Cu	=	3.46
Zn	=	0.79
S	=	17.63
		100.00

This latter result must be taken as establishing the nature of Alaskaite, beyond reasonable doubt.

But on examining some other specimens qualitatively, which appeared to be identical in physical characters with the preceding one, I could not at first produce the crimson silver coating. Suspecting an essential difference I made upon the same powder three analyses the mean of which (closely agreeing) is as follows:

Bi = 51.35	Bi	= 51.35	: 208	=		0.2468
Pb = 17.51	Pb	= 17.51	: 207.2	=	0.0845	0.1308
Ag = 3.00	Ag	= 3.00	: 216	=	0.0138	
Cu = 5.38	Cu	= 3.74	: 126.4	=	0.0295	
Fe = 1.43	Zn	= 0.20	: 65	=	0.0030	
Zn = 0.20	S	= 16.21	: 32	=		0.5080
S = 17.85	(Cu Fe) S_2	= 4.71				
Insoluble = 2.83	Barite	= 2.83				
99.55						

$$R : Bi : S = 1 : 1.887 : 3.883 = 1 : 2 : 4$$

This then is the same mineral, except that the greater part of the silver is replaced by lead.

We have then in Alaskaite a complete type of the sulphosalts of the first order, according to Rammelsberg's symbol:

$$(\acute{R}_2, \ddot{R}) S + r^2 S^3$$

to wit $$(\ddot{Pb}_1 \ddot{Zn}_1 Ag_2 Cu_2) S + (Bi^2 Sb)^2 S^3$$

Of this type several members are known, but the copper bismuth glance from Schwarzenberg, and perhaps Domeyko's ore from Copiapo contain bismuth exclusively on the negative side.

The crystallographic symmetry of all the members of this type is probably *orthorhombic*.

A specimen from the Alaska mine, which had been sent to me as bismuth silver-ore, being composed of quartz, barite, chalcopyrite and what

appeared to be gray copper was pulverized as a whole, and analyzed with the following result:

		Calculated			
Sb	= 10.10	Sb_2S_3	= 13.68 : 340 = 0.0402	} 0.0530	
Bi	= 5.05	Bi_2S_3	= 6.59 : 512 = 0.0128		
Cu	= 14.97	Cu_2S	= 17.01 : 126 = 0.1076	} 0.1673	
Pb	= 3.84	PbS	= 4.04 : 239 = 0.0169		
Ag	= 0.70	ZnS	= 3.84 : 97 = 0.0396		
Zn	= 2.56	Ag_2S	= 0.80 : 248 = 0.0032		
Fe	= 1.23	$(Cu_1 Fe) S_2$	= 4.03		
S	= 11.53	Quartz, etc.	= 48.55		
Insoluble	= 48.55				
	98.55				

If the gray substance be considered homogeneous then its molecular ratio will be

$$RS : r^2S^3 = 3.1 : 1$$

But gray copper has the ratio of 4 : 1. If the bismuth sulphide be now eliminated with the corresponding positive sulphide in the Alaskaite ratio of 1 : 1, then we get for the ratio of the rest

$$RS : Sb_2S_3 = 3.86 : 1$$

that is nearly the gray copper ratio.

It is made even more probable that such a mixture be here in existence, by qualitative tests upon a large specimen, weighing several kilograms of the massive gray mineral. These tests indicated very varying percentages, by the intensity of bismuth reaction from different points of the piece.

It is a matter of remark from a genetic point of view, that we find in this vein nests of Alaskaite quite free from the gray copper, while the latter seems to be mixed generally with the former in other places whenever it predominates.

The Auriferous Gravels of North Carolina. By H. M. Chance, M.D.

(Read before the American Philosophical Society, July 15, 1881.)

The belt of auriferous gravel stretching in an almost unbroken line from the New England States to Alabama, is broadest in North Carolina, where it has also been more productive in the past, and promises greater results in the future than in any other State through which it passes.

Yet notwithstanding the flattering prospects apparently presented by these gold fields, the companies organized to work them have rarely at-

tained practical success even for a short period; they have, in fact, almost without exception, failed to pay dividends, and their stock is now a drug in the market.

But a period of excitement has again been inaugurated, capitalists are again investing in mines long since abandoned as unremunerative, and old Californian miners are leaving the West for the more glittering prospects of the East, where they say the gravel is much richer.

While making an examination of mineral lands in Central and Western North Carolina, I recently noted a series of facts that may explain in general why these fields have not been remuneratively productive in late years, although the gravel does contain a larger average amount of gold per cubic yard than many Western placers now profitably worked.

When one inquires why the workings are not financially successful, he is immediately met with the statement that the mines paid handsomely prior to the California excitement in '49, when the Western gold fever caused a suspension of operations; that the civil war caused a second stoppage; and that there are many reasons why they have not been systematically worked since the war.

These statements are honestly made, and are to some extent true; but from 1855 to 1860, several companies were working, and with very discouraging results, and since the war several mining operations have been commenced, but discontinued—because they were not remunerative. It cannot be claimed that these operations were unsuccessful because they were not prosecuted for a sufficiently long period, for in placer workings, the results, if any, are quickly attained.

The early workings, prior to the California discoveries, were undoubtedly remunerative. They were confined principally to the gravel deposits found along the smaller streams, and their tributaries, notably on the First and Second Broad rivers, and on Silver and Muddy creeks in Rutherford, Burke and McDowell counties. The gravel was worked by panning, by the rocker and "*long-tom*," and it is also claimed at one place at least, by sluicing with a head of water.*

A brief review of the geological peculiarities of the region will explain the great difference between these old workings, and the gravels now being washed.

In the Geology of North Carolina by Prof. W. C. Kerr, page 156, the gold gravels are referred to the Champlain period, and are described as beds of *till* or decomposed rock (*initial drift*), sometimes in place, sometimes several hundred feet lower on the hillside than the rocks from which they were derived by disintegration.

The truth of this statement is apparent to every careful observer, and this view is now generally accepted among those practically engaged in working these deposits.

The gold seems to be irregularly distributed through the so-called "slates" (mica schist, micaceous gneiss, hornblende, schist, etc.), either in

*The first use of this method is generally credited to California.

thin quartz veins or disseminated through the mass. As erosion progresses, the decomposed schist is converted into gravel, the lighter and finer particles of clay, mica, etc., being easily washed out by the percolation of rain water, leaving the heavier minerals and the larger quartz fragments behind. Thus an essentially concentrating process is and has been constantly progressive since the Glacial period, and the gravel now found lying as a surface covering from one to thirty feet thick may, and probably does, represent several times its thickness of rock, the coarser and heavier fragments of which alone remain.

The thickness of the gravel in the South Mountain region probably averages from six to nine feet, but I consider that this represents the remains of at least twenty or thirty feet of rock. On this basis the gravel should contain more than three times as much gold as an equal bulk of the mother rock—it is, in fact, found to be much richer.

The streams draining this region have carried away millions of cubic yards of this gravel. The old river bed workings in California have shown that all streams act as natural sluices, separating and concentrating the gold and heavier minerals from rocks of less specific gravity, and this action has undoubtedly been operative in these North Carolina streams. The gravel washed into the smaller stream beds dropped its coarser gold before being carried out into the main water courses, and we consequently find that the rich washings were nearly all found in the beds of the small creeks and their tributaries.

These were thoroughly worked over during the early mining excitement, prior to the exodus in '49, yielding to hand panning and to work with the rocker and long-tom, from two to ten dollars a day. They have since been reworked; at some places the same gravel has been washed three or four times. It was very rich, necessarily so, for working a stream down to bed-rock* is like cleaning up a sluice—it contained the gold dropped from millions of cubic yards of gravel, the accumulation (*concentrates*) of thousands of years.

There are a few localities where these stream gravels are as yet undisturbed. They will yield good returns, but their area is very small.

The vast bulk of gravel now remaining to be worked is hill gravel; its thickness will not exceed an average of nine feet, and it is of varying degrees of richness.

On some tracts gravel may be found yielding from one to ten colors to the pan, and work done with a rocker may show from five grains to a pennyweight to the cubic yard, a most flattening prospect to the Western hydraulic miner; but such results are rare. I am inclined to think that five or six grains to the cubic yard is as much as can be expected from an average run of fair gravel.

The important question, now being solved in a practical way on the

*The bed-rock was usually not more than two or three feet beneath water level.

ground, is: Can these deposits be profitably worked by hydraulic mining? The question may be answered both in the affirmative and in the negative.

At a few places where the gravel is both rich and thick—ten feet or more—and water can be obtained in sufficient quantity at moderate cost, hydraulic mining may be successful—but

1. A large working area is necessary.
2. The closest economy must be exercised, and
3. A relatively small amount of capital invested.

A large area is necessary, because the deposit is not thick; assuming an average thickness of four yards, one acre would yield but 19,360 cubic yards of gravel, and one-fourth of this being top gravel and soil might contain very little gold, as the gold is often concentrated in the lower layers, sometimes in a "pay-streak," near the bed-rock. This "pay-streak" is at times quite thin—one, two or three feet thick, but the gold is more usually disseminated through the mass.

The difference between the cost of working these thin deposits, and the enormously thick gravels of California and Oregon will be readily appreciated by the hydraulic engineer, and to this difference is due the fact that although these gravels are much richer than many Western deposits successfully worked, the prospect of remunerative mining in this region is much less.

In some localities the cost of bringing water will be very great; ditches ten or twelve miles long being necessary. At the Sam Christian mine, on the Yadkin river, arrangements are even being made to *pump* the water!

It will also be difficult to obtain sufficient fall to carry off the tailings, for some of the richest of the hill gravels has been found in comparatively low ground, where much of the material must be moved by hand. I noted one mine working under just such conditions, that was yielding as well as the best can be expected to average. The gravel was about four yards thick, the gold occurring principally in a pay-streak near the bed-rock. The lowermost four or five feet was moved by hand, some pick work being required.

The cost for labor was about 64 cents per superficial square yard, and the yield averaged over a considerable area one pennyweight—85 cents. Labor 75 cents per day. This shows a profit of 21 cents per superficial square yard or 5.25 cents per cubic yard; but these figures do not include the cost of superintendence, mercury, wear and tear, etc. When these items are included, it can easily be seen that the operations were being carried on at an actual loss, for not more than one hundred yards were washed per diem, and the profit on this would not pay the expenses of management.

A trial of General Strong's injector dredging machine* is now being made on the gravels in the bed of Silver creek. It seems better adapted to working on river bottoms than on these small South Mountain streams.

* Described by Dr. R. W. Raymond, in Vol. viii, Transactions of the American Institute of Mining Engineers.

I have reason to think from what I have seen, that there are comparatively few localities where these North Carolina hill gravels can be successfully worked at present; that in any event the returns—considering the risk—will be small; that no "bonanza" need be expected, though local deposits of very rich gravel will undoubtedly be found; and that no operations can be successful unless the *strictest economy* is observed in all the details both of *management* and *working*.

Stated Meeting, July 15, 1881.

Present, 4 members.

Vice-President, Dr. LeConte, in the Chair.

A letter acknowledging the receipt of certificate of membership was received from Ast. Roy. G. B. Airy, dated Royal Observatory, Greenwich, June 18, 1881.

Acknowledgments of the receipt of Proceedings were received from the Smithsonian Institution (boxes of 302 addresses for distribution; and 108); the Prag Observatory (104, 105, 106; List); R. Danish S. S. (105, 106; List); Vermont Historical Society (107); Mus. C. Z. Harvard Collection (108); A. Agassiz (108); T. P. James (108); New Bedford Public Library (108); United States Military Academy (108); Poughkeepsie S. N. S. (108); J. J. Stevenson (108); Buffalo S. N. S. (108); F. A. March, Easton, Pa. (108); Chicago Historical Society (108); and State Historical Society, Wisconsin (108).

Donations for the Library were received from the New Zealand Institute; the Danish Society of Sciences; Accademia dei Lincei; Revista Euskara; Society C. Geog., Bordeaux; Geographical Society, Paris; Mus. N. H., Paris; Royal Belgian Academy; Royal Astronomical Society and Meteor. Com. London; Boston N. H. S.; American Oriental Society; Har-

vard University; New Jersey Historical Society; Franklin Institute, Journal of Pharmacy, American Journal of Medical Science, Medical News and Abstract, Pennsylvania Magazine H. and B., Philadelphia Library Company, Alumni Association, University of Pennsylvania; J. W. Powell, Washington; Jed. Hotchkiss, Staunton; California Academy of Sciences, and Mariano Barcena, of Mexico.

The death of Mr. W. E. Dubois, at Philadelphia, July 14, 1881, aged 70, was announced by Dr. LeConte with appropriate remarks.

The death of Dr. Geo. Rolleston, at Oxford, England, June 17, 1881, aged 56, was announced by the Secretary.

The following communications were presented:

"On the Auriferous Gravels of North Carolina, by H. M. Chance, M. D." (See page 477 above.)

"The Brain of the Cat, *Felis domestica*. 1. Preliminary account of the Gross Anatomy. With four plates. By Burt G. Wilder, M. D. Professor of Anatomy, etc. in Cornell University, and of Physiology in the Medical School of Maine."

"The Vague Nerve in the Domestic Cat, *Felis domestica*. With three plates, by T. B. Stowell."

Balloting for new members was postponed to the 21st of October next.

Pending nominations 934 to 940 were read, and the meeting was adjourned.

Stated Meeting, September 17, 1881.

Present, 3 members.

Prof. COPE, in the Chair; Dr. HORN; Mr. LESLEY.

Letters of acknowledgment were read from the London Zoölogical Society (XV ii; Cat. III; 97—106); Leipsig Astronomical Society (106, 107); Teyler Foundation (107, 108); Holland Society (XV iii, 107, 108); Brown University (108); and Yale College (108).

Letters requesting numbers of Proceedings for the completion of sets were received from Prof. W. D. Whitney and Dr. Jacob M. Dacosta.

Donations were reported from the Academies at St. Petersburg, Berlin, Bruxelles, Rome and New York; from the Observatories at San Fernando, Greenwich and Cape Town; from the Society at Bonn; the Geographical Societies at Bordeaux and Paris; the London Astronomical and Antiquarian Societies; from Prof. Steenstrup, Dr. Schäffler, Herr Tischner, Herr Freytag, M. Renevier and Prof. W. Huggins; the Revista Euskara, Revue Politique, Chemists' Journal, and London Nature; the Annales des Mines; the Cobden Club; the Victoria Institute; Essex Institute; Boston S. N. H.; R. C. Winthrop, Dr. S. A. Green; Yale College; American Journal of Science; New York Academy; American Chemical Society; Metropolitan Museum of Art; New York Mercantile Library Association; Princeton Museum; Franklin Institute; College of Physicians; Journal of Pharmacy; Medical News; C. A. Ashburner; P. W. Sheafer; the National Museum; U. S. Bureau of Education; Buffalo N. H. S.; American Antiquarian, and J. Hotchkiss, of Virginia.

Prof. Cope communicated a paper entitled, "On some Mammalia of the Lowest Eocene beds of New Mexico."

Pending nominations Nos. 934 to 942, and new nominations Nos. 943, 944, 945, were read.

There being no quorum present, several items of business were postponed for consideration at the next meeting.

On some Mammalia of the Lowest Eocene beds of New Mexico. By E. D. Cope.

(Read before the American Philosophical Society, Sept. 17, 1881.)

MESONYX NAVAJOVIUS, sp. nov. Smaller than the two known species, and with the crowns of the molars more compressed and the blades of the heels of the inferior series more acute. Molars seven, the first one-rooted. Last molar with a cutting heel like the others, and with the penultimate, with a rudimental anterior inner cusp. All the molars with an anterior basal tubercle except the first, second and third. No basal cingula. Principal cusp elevated and compressed, as in the premolars of *Oxyæna.* Enamel minutely rugose. Mandibular rami and inferior canine teeth compressed, the angle of the latter not inflected. Length of inferior molar series M. .078 ; do. of premolar series .046 ; fourth premolar, length of base .010 ; elevation of cusp .008 ; second true molar, length .012, elevation .010 ; width of heel .005 ; depth of ramus at .020 ; diameter of base of crown of canine, vertical .009.

PERIPTYCHUS CARINIDENS, gen. et. sp. nov. Creodontium. *Char. Gen.* No distinct sectorial teeth, the first and second true inferior molars similar. They support a principal median cusp, a broad heel and a prominent anterior cingulum. The heel is more or less divided into tubercles ; the anterior cingulum is on the inner side, and represents the anterior cusp of a sectorial tooth. On the inner side of the principal cusp a cingulum rises, forming a flat internal tubercle. Last molar not smaller than the others ; premolars unknown.

This genus belongs to the *Amblyctonidæ* with *Amblyctonus* and *Palæonyctis.* It differs from both in the rudimental character of the anterior cusp, and from the former, in the presence of the internal tubercle. In *Mesonyx* the heel has a median cutting edge. *Char. Specif.* Parts of both mandibular rami and the shaft of a humerus represent this species. They indicate an animal of the size of the red fox, but much more robust. The mandibular ramus is rather shallow and thick, and the molars are not large. The heel of the penultimate supports three tubercles, of which the external is the largest. The anterior cingulum supports a small cusp, and then rises to the internal tubercle, which is compressed. The sides of all the cusps are marked with distinct, well separated, vertical ridges. Each extremity of the internal cusp is connected with the principal cusp by a ridge. The first true molar has fewer cusps. Those of the heel are scarcely distinct, and form a border which rises prominently into the flat internal tubercle, which forms a narrow longitudinal blade. The anterior cingulum has no cusp and does not rise into the inner tubercle. The principal cusp has a strong entering groove next the inner tubercle. Length of crown first molar .0115 ; width of do. .006 ; elevation of do. .006. Length of second molar .011 ; width of do. .007 ; elevation of do. .0065. Depth of ramus at do. .020. The species is a good deal smaller than the *Amblyctonus sinosus.*

TRIISODON QUIVIRENSIS, gen. et sp. nov. *Char. gen.* Derived from the lower jaw. Probably only three premolars. True molars alike, consisting of three anterior cusps and a heel. The cusps are relatively small and the heel large. Of the former the internal is much smaller than the external, and the anterior is rudimental, being merely a projection of the cingulum. The cutting edges of the large external cusp are obtuse. The heel is basin-shaped, and its posterior border is divided into tubercles, of which the external is a large cusp. The fourth premolar has no anterior inner tubercle, so that the anterior part of the crown consists of a compressed cutting cusp. The heel has two well-developed posterior cusps. The third premolar has a similar principal trenchant cusp, but a smaller heel. Canines large.

This genus differs from *Herpetotherium* and *Ictops* in the simplicity of its fourth inferior premolar, and from *Stypolophus* and *Deltatherium* in the rudimental character of the accessory anterior cusps of the true molars, as well as in the three premolars. The rudimental anterior cusp of the true molars, with the three similar true molars, separates it from *Palæonyctis*, and the presence of a conic inner cusp of the same indicates it as different from *Amblyctonus* and *Periptychus*. It is not possible to state whether *Triïsodon* must be placed in the *Amblyctonidæ* or not, on account of the absence of the superior molar teeth.

This specimen of the type species of this genus is instructive as showing the succession of premolar teeth. Both the third and fourth premolars have temporary predecessors. The predecessor of the fourth premolar differs much from it in form, and is essentially identical in all respects with the true permanent molars. The crown of the predecessor of the third premolar is wanting, the roots only remaining in the jaw.

The permanent third premolar was protruded before the permanent fourth. Which temporary tooth of *Triïsodon* is homologous with the single one of the *Marsupialia* pointed out by Professor Flower?* As the additional permanent teeth of the placental *Mammalia* must have appeared later in time than the one already found in the implacentals, they must be those later protruded; hence the fourth tooth in the jaw of *Triïsodon* must be regarded as homologous with the fourth premolar of a placental, which is the last of that series to appear. If this be true, the tooth which follows the shed tooth of the Marsupials is not the fourth premolar, as supposed by Professor Flower, but the third premolar. This view is confirmed by the fact that the milk tooth displaced by the fourth tooth in *Triïsodon* resembles in all respects the true molars, just as the permanent tooth occupying the same position does in *Didelphys* and some extinct eocene genera. This goes to show that this tooth, permanent in marsupials, is temporary in placentals, and that, in spite of its form in the former group, it is the fourth premolar, and not the first true molar, as supposed by Professor Flower. Thus the posterior milk-molar of diphyodonts is a permanent tooth in the *Marsupialia*.

* Transactions of the Royal Society, 1867, p. 631.

This observation confirms my conclusion that the *Creodonta* form a group intermediate between the *Marsupialia* and *Carnivora*. I may add that in *Triisodon* the inferior border of the lower jaw is not inflected posteriorly.

Char. specif.—Size about that of the wolf. Inferior canine directed upwards, its section nearly elliptic; a faint posterior, no anterior cutting edge. Fourth premolar rather large, with an anterior basal cingulum which is angulate upwards, and is not continued on the inner side of the crown. Cusps of the heel each sending a ridge forwards, the internal lower, obtuse and descending to base of inner side of large cusp; the external larger, with an acute anterior cutting edge continuous with the cutting edge of the large cusp. True molars with an external, but no internal basal cingulum. Border of heel with one large and three smaller tubercles, the former with, the latter without, anterior cutting edge. Enamel of all the teeth nearly smooth. All the cusps are rather obtuse. *Measurements.*—Length of inferior molar series: M. .080; long diameter of base of canine .013; length of true molar series .044; length of base of Prem. IV. .016; elevation of crown of do. .014; length of base of M. II. 016; width of do. in front .011; elevation of do., .014. The measurements of the jaw are not given, as the animal is not adult, the last molar not being yet protruded.

From the lowest Eocene beds of New Mexico.

Deltatherium fundaminis, gen. et sp. nov. *Char. Gen.* Fam. *Leptictidæ*, agreeing with *Ictops* and *Mesodectes* in possessing an internal tubercle of the third superior premolar, but differing from both in having but one external cusp of the fourth superior premolar. *Char. Specif.* Represented by the dentition of both maxillary bones minus the canines. The second premolar is convex on the inner face. The base of the third is a nearly equilateral triangle. The bases of the true molars are triangles, with the bases external. The internal angle supports an acute cusp, and has a posterior basal cingulum, which is very strong in the last three molars. The two external cusps of the first and second molars are situated well within the base, which is folded into a strong cingulum. This cingulum develops strong anterior and posterior angles. This is the largest species of the family yet discovered. Extent of series of last six molars, M. .045; of true molars .026; diameters of fourth premolar, anteroposterior .0074; transverse .0076; do. of second true molar, anteroposterior .0087; transverse .0100. This species was a fourth larger than the common opossum, and very much resembles it in dental characters.

posed than the internal, and are somewhat contracted inwards. In the unworn crown there is a distinct anterior inner cusp, which is soon confounded on attrition. The heel of the last premolar has a crescentic section, the internal horn the narrower. The anterior lobe is a robust cone. The base of the second and third premolar is oblique to the axis of the ramus outwards and forwards. It is possible that there is a minute first premolar filling the short space between the second and the canine. No cingula; enamel obscurely plicate, ramus robust. Length of molars minus the last .0465; length of base of first true molar .010; width of do. .009; elevation of crown do. .0055; length of base of fourth premolar .011; width of do. .008; elevation of crown of do. .0065. Anteroposterior diameter of base of crown of canine .010. Depth of ramus at first true molar .023; width of do. at do. .013. This genus differs from *Esthonyx* in the form of the fourth premolar. In the latter the anterior lobe is compressed and trenchant. The species is larger than any of that genus, and nearly equal to the *Ectoganus gliriformis*.

CATATHLÆUS RHABDODON, gen. et sp. nov. *Char. Gen.* With this genus I commence descriptions of several genera with bunodont dentition, which has some resemblance to that of some of the hogs. The one above named, with *Mioclænus*, remind one of *Tetraconodon* Falc. and Lydd., in the enlarged proportions of their premolar teeth. I compare the genera as follows, introducing a probably perissodactyle form (*Protogonia*) for comparison:

I. Third and fourth superior premolars one or two lobed externally, and with internal lobes.

a. Superior premolars with two external lobes; inferior fourth with two median cusps.

Intermediate tubercles; premolars not enlarged............. *Phenacodus*.

aa. Superior premolars enlarged, generally with one external cusp.

β. A posterior internal cusp of superior molars;

Intermediate tubercles present; last inferior premolar with inner cusp; *Catathlæus*.

Intermediate tubercles wanting, replaced by branches of an internal V; no cusp on inner side of last inferior premolar........ *Anisonchus*.

Intermediate tubercle present, connected with anterior inner by ridges; inferior molars with Vs............................ *Protogonia*.

ββ. No posterior inner cusp of superior molars.

Intermediate tubercles present; no inner lobe of last inferior premolar *Mioclænus*.

II. Superior premolars 1, 2 and 3 without inner lobe; third with three external lobes (Pictet).

Premolars compressed.. *Dichobune*.

In the genus *Catathlæus* the development of the premolars is remarkable while the true molars are relatively small. The last three superior premolars have an elevated internal crescentic cingulum homologous with

the inner lobe of the fourth superior premolar of the ruminants. The general character of the true molars is that of *Phenacodus*. Parts of two or three individuals of this species have come into my possession, one of which includes nearly all of the molar dentition of both jaws. The external cusp of the superior premolars is compressed conic, and the internal cingulum extends to its *anterior* base in the second, third, and fourth. The crown of the last true molar is about as long as wide, while that of the first is wider than long. Each supports seven cusps; two subconic external, and one large median internal, which is connected by ridges with a small anterior and posterior median. Then there are a small anterior and posterior internal, making three internal. The internal crest is distinct from the principal cusp in the inferior premolars III and IV, but unites with it in the II; it supports on the IV an anterior, a median and a posterior cusp, the latter forming part of the rather narrow heel. The true molars I and II have seven tubercles, the four principal ones, and three smaller, one anterior, one posterior, and one median. On the third the posterior forms a large heel. All of the molars, but especially the premolars, have the enamel thrown into sharp vertical parallel folds, in a manner I have not seen in any other mammal. Length of six superior molars .067; length of three true molars .029; length of base of third premolar .012; width of do. .012; width of base of first true molar .010; do. of third true molar .009; length of do. .010. Length base fourth inferior premolar .012; width do. .010; length of third true molar .0115; width of do. .009. The teeth indicate an animal of the size of the peccary.

ANISONCHUS SECTORIUS, gen. et sp. nov. *Char Gen.* This is derived from the superior P-m. IV and M. I and II, and from all the inferior molars of three individuals. The superior teeth are accompanied by a ramus mandibuli, which contains alveoli of all the inferior molars, and the crowns of the P-m. IV and M. II. The leading characters have been given above. The inner posterior lobe is more prominent in this genus than in any of the others, and has a V-shaped apex. It projects further inwards than the anterior inner lobe. It is represented by a mere tubercle of the cingulum in *Mioclænus*. In the lower jaw the last premolar is quite simple, consisting of a principal cusp, and a non-cutting heel. The second true molar has intermediate anterior and posterior cusps. The genus differs from *Pantolestes* in the more numerous tubercles of the molars, and in the fact that the anterior inner tubercle of the true molars is not double. It may, however, be allied to that genus.

Char. Specif. The fourth superior premolar covers a larger base than either of the true molars. The external cusp has a base extended anteroposteriorly, but the apex is conical, and there are no basal tubercles. The inner cusp has a crescentic base as in *Catathlæus*, but the apex is narrowed and compressed conic. The external tubercles of the true molars are subconic, and do not develop any external ridges. They are connected by the crescentic slightly angular crest, whose apex forms the inner ante-

rior boundary of the crown. This crest is not divided into parts homologous with the intermediate tubercles. The crowns of the M. I and II are surrounded by a basal cingulum, which in the M. I develops a tubercle at the anterior external angle. No internal or external cingulum on P-m. IV. Enamel nearly smooth.

The ramus of the mandible is rather slender anteriorly. The P-m. IV is robust, and the cusp is behind the middle of the base of the crown. The heel is short and narrow, and has a raised border, connected with the base of the main cusp. The cusps of the second true molar are elevated and conic, the anterior external the highest, the others subequal. The base of the posterior pair is a little narrower than that of the anterior pair. There is no central tubercle as in *Catathlæus rhabdodon*, and no basal cingulum on either tooth.

Measurements.		M.
Length of three superior molars		.0160
Diameters superior P-m. IV	anteroposterior	.0055
	transverse	.0070
Diameters superior M. I	anteroposterior	.0052
	transverse	.0060
Length of inferior molar series		.0610
" " " true molar series		.0160
Diameters inferior P-m. IV	anteroposterior	.0060
	transverse	.0040
Diameters inferior M. II	anteroposterior	.0050
	transverse	.0040
Depth ramus at M. II		.0090

A number of minor points will distinguish this species from those included among the *Mesodonta*, and especially those of *Pantolestes*, which it most resembles. The molar teeth are narrower behind, and the fourth premolar is larger. It is *Mioclænus sectorius*, American Naturalist, October, 1881, p. 831.

MIOCLÆNUS TURGIDUS, gen. et sp. nov. This genus differs from *Catathlæus* in the structure of the inferior premolars, which are without internal crest or cusp. The inner lobe of the superior premolars is less developed than that genus. In the present species the characters of *Mioclænus* are best seen in the subconical tubercles of the premolars, particularly that of the heel of the fourth inferior premolar. In the other three species this heel is more of a crest and is connected with the principal cusp by a low ridge. The four species may be characterized as follows:

a. Cusps of last premolars conical in both jaws.

Size medium. Last lower molar disproportionately small; cusps low; two anterior inner distinct; true molars, .018 .... *M. turgidus.*

aa. Fourth superior premolar with flattened external and conic internal cusp; inferior unknown.

Size medium; fourth upper premolor equilateral; all cusps acute; true molars .0165..*M. subtrigonus.*

aaa. Cusps of last premolars compressed in lower jaw.

Least. Second and third lower true molars subequal; cusps, especially the internal, elevated; anterior inner confluent into an edge; true molars, .013..*M. angustus.*

Largest; cusps of inferior molars obtuse; P-m. III .008, its heel short and small...*M. mandibularis.*

Medium; last inferior molar larger than penultimate; true molars, .014; P-m. III .006................................*Anisonchus sectorius.*

Of *M. turgidus* there are two specimens; and of *M. subtrigonus*, *M. angustus* and *M. mandibularis* one each.

In the *M. turgidus* there are no cingula on the fourth premolar. It is wider than long, and the external face is a little flattened. The tubercles are conic; the external has a small one at the anterior base, and a rudiment at the posterior base, and there is a low one on the posterior side at the middle. The second true molar is wider than the first. The tubercles are all round in section. Besides those already mentioned, there is a rudiment of a posterior inner on the first, which is represented by a cingulum on the second. The latter has basal cingula all around except on the inner side; the same are visible on the first true molar in a rudimental condition. Enamel nearly smooth.

The inferior molars are of robust proportions. Their sizes are, commencing with the largest: P-m. IV; M. II; M. I; M. III. The last molar is only half as large as the penultimate. It has two anterior and an external lateral tubercles, and a heel. On the penultimate molar, there are two anterior tubercles with a trace of anterior inner; also a broad flat heel, with a low tubercle on the external side. The constitution of the first true molar is identical. The fourth premolar has a rudimental heel consisting of a low tubercle only. The principal cusp is conic and is over the middle of the transverse diameter, and a little behind the middle of the anteroposterior diameter. No cingula. Enamel nearly smooth.

Measurements.		M.
Maxillary bone.		
Length of base of P-m. IV, M. I and M. II		.0175
Diameters base P m. IV	anteroposterior	.0055
	transverse	.0065
Diameters base M. I	anteroposterior	.0060
	transverse	.0070

Measurements. M.

Diameters M. I	anteroposterior	.0060
	transverse	.0060
Diameters M. III	anteroposterior	.0055
	transverse	.0043
Depth of ramus at M. I		.0115
Thickness " " "		.0085

Mioclænus subtrigonus, sp. nov. Represented by a portion of a cranium anterior to the orbits and lacking the extremity of the muzzle, distorted by pressure. It exhibits nearly all of the molar teeth. The species differs from *M. turgidus* in the greater acuteness of all its cusps, and in the equilateral form of the fourth premolar. It is too large to belong to the *M. angustus*, which is represented by a mandible only; and too small to be the *M. mandibularis*, whose maxillary dentition is unknown.

The inner borders of the molar teeth are shorter than the outer, especially in the last two molars. The last true molar is smaller than either of the others. The cusps are all subconical, but the internal is connected with the intermediate by ridges, which give it a triangular section. The latter form a V, homologous with that in *Anisonchus*, but not so distinct, and the intermediate tubercles are not lost in its branches as in that genus. The posterior inner lobe of that and other genera, is represented by a thickening of the cingulum. This cingulum extends entirely round the P-m. IV and M. I, and M. II; the M. III is injured. The sides of the base of the P-m. IV are slightly concave. The enamel of all the molars is wrinkled.

Measurements. M.

Length of bases of last five molars		.0285
Diameters of base of P-m. IV	anteroposterior	.0060
	transverse	.0050
Diameters of base of M. I	anteroposterior	.0060
	transverse	.0060
Diameters base of M. II	anteroposterior	.0060
	transverse	.0075
Diameters base of M. III	anteroposterior	.0040
	transverse	.0060

Mioclænus angustus Cope, American Naturalist, 1881, October (September 22d), p. 831. The least species of the genus, with the teeth about the size of *Hyopsodus paulus* Leidy, but with more robust jaw. The molar teeth diminish in size regularly posteriorly from the P-m. IV. They all have three subequal posterior cusps which are less elevated than the anterior ones. The median is enlarged into a heel on the last tooth. The anterior are opposite, and the external is larger than the internal. There is no anterior internal. The external wears into an anteroposterior narrow grinding surface, which looks like a combination with an anterior median. The latter is, however, not separate on the least worn molars. The

anterior outer cusp increases in size anteriorly, and is the large cusp of the P-m. IV. It sends a branch backwards on the inner side of the crown which forms the edge of the narrow concave heel. There are no cingula except a short one on the anterior corners of the base of the crown of the P-m. IV. Enamel obscurely wrinkled.

Measurements.		M.
Length of posterior four molars		.0180
Diameters of P-m. IV	anteroposterior	.0050
	transverse	.0035
Diameters of M. I	anteroposterior	.0050
	transverse	.0085
Diameters of M. II	anteroposterior	.0040
	transverse	.0032
Diameters of M. III	anteroposterior	.0045
	transverse	.0030
Depth ramus at M. I		.0110
Thickness " " "		.0060

PHENACODUS PUERCENSIS, sp. nov. Three individuals. Last superior molar smallest; first and second true molars with six tubercles, two external, two median and two internal. A strong basal cingulum except on inner side. Inferior true molars besides the usual five tubercles, furnished with an anterior ledge with a tubercle at its interior extremity. A weak external basal cingulum. A little larger than the *P. vortmani*. Length of superior true molars M. .021; length of base of crown of M. III .006; do. of M. I .008; width of do. .008; length of base of crown of inferior M. III .0085; width of do. in front .006; depth of ramus at M. I .019.

PHENACODUS ZUNIENSIS, sp. nov. The least species of the genus, represented by the mandibles of two individuals. The first and second true molars are narrowed in front, and there is no distinct anterior ledge, only a minute anterior inner tubercle. The external cingulum is more distinct and the enamel is wrinkled The fourth premolar has a short base and the inner cusp is much smaller than the principal one; it has a wide heel and an anterior basal tubercle. Length of true molars, M. .018; of last true molar .006; of base of first true molar .006; width of do. .004; depth of ramus at do. .011.

PROTOGONIA SUBQUADRATA, gen. et sp. nov. Fourth superior premolar with one external and one internal lobe. True molars with two external,

rior molars, if they are properly identified; and in the superior molars. The anterior transverse crest of that genus is represented in *Protogonia*, but not the posterior. This is replaced by a low ridge running across the course it pursues in *Hyracotherium*. The posterior median tubercle is also not found in the latter genus. *Protogonia* differs from *Limnohyus* in the subconic character of the external lobes of the superior molars. If the tubercles, excepting the posterior inner, should be converted into crescents, the genus *Meniscotherium* would be produced.

Char. Specif. Probably two specimens; one supporting three superior molars; the other including damaged superior molars and the last two inferior molars. The animal was about the size of the red fox. The external cusp of the fourth superior premolar is flattened externally, and has a small lobe on its posterior edge. The inner tubercle is conic and is separated by a tubercle from the anterior base of the external. True molars without external ridges. The external cusps of the true molars are lenticular in section. The posterior inner cusp is in nearly the same anteroposterior line with the anterior, its section about equaling that of the intermediate cusps. The first and second molars have an external, an anterior and posterior, but no internal, basal cingula. The enamel is somewhat wrinkled where not worn.

The heel of the last inferior true molar is elevated, and its worn surface forms the extended posterior branch of the posterior V. The posterior edge of the penultimate molar is elevated and curved forwards on the inner side of the crown. The anterior cusp forming the angle of the V of this tooth, is higher than the posterior angular cusp, but the anterior limb descends rapidly as in *Coryphodon*. A weak antero-external, and postero-external cingula. Enamel wrinkled where not worn.

Measurements.		M.
No. 1.		
Length of bases of three superior molars		.025
Diameters of superior P-m. IV	anteroposterior	.0066
	transverse	.0086
Diameters of superior M. I	anteroposterior	.0085
	transverse	.011
Diameters superior M. II	anteroposterior	.009
	transverse	.011
No. 2.		
Length of bases of last two inferior molars		.0225
Diameters of last inferior molar	anteroposterior	.0114
	transverse	.0066
Diameters of inferior M. II	anteroposterior	.0112
	transverse	.0080
Depth of ramus at M. II		.0240
Thickness " " "		.0110

MENISCOTHERIUM TERRÆRUBRÆ, sp. nov. My specimens of this species embrace the dentition of several individuals.

The dimensions of the superior molars increase to the penultimate, while the external and posterior sides of the last molar are contracted. reducing its size. The external faces of the external Vs of the true molars are considerably impressed; those of the premolars are nearly flat.

The second premolar is two-rooted, and has a compressed crown, without either heel or cingulum, except a thickening of the posterior base. The base of the crown is triangular. The external plate of the third premolar is simple, and is connected with the internal cusp by a cingulum on the posterior base of the crown. The crown is transverse, and the inner tubercle rather small. The fourth premolar is much larger than the third. Its external plate is divided into two apices, which are not impressed. Their external faces are separated by a faint ridge, and are divided medially by a faint ridge. The anterior external angle is rather prominent. The anterior and a posterior cingulum extend to and round the inner base of the interior tubercle. Within the anterior external apex, is a well developed intermediate crest parallel to it; and there is a corresponding crest within the posterior external apex. This one turns inwards at its posterior extremity, which is on the posterior cingulum.

The anterior angle or horn of each external crescent of the true molars is very prominent. They are sections of short vertical ridges, which unite near the base of the crown, giving abruptness to the impression of the external surface of the anterior lobe. The middle of each face has a faint median ridge. The two molars have an anterior basal cingulum, but no posterior or internal, excepting a trace between the bases of the internal lobes. The anterior intermediate crescent is quite parallel with the external; the anterior internal tubercle has a slightly V-shaped section. The posterior inner tubercle is quite confluent with an oblique intermediate crest, as in *M. chamense*. In the last true molar, as there is only one internal tubercle, this crest is short, terminating at the posterior border. The last true molar is like the last premolar, except in its two impressed external crescents.

A fragment of the right branch of the lower jaw supports two molars, and the alveoli of two others, all of which have two roots. These teeth are the four premolars, although the last one has the form of the first true molar. Should my surmise be correct, then the third premolar has nearly the same form and structure as the fourth. The anterior horn of its anterior V is not produced quite so far inwards as in the fourth tooth. At the point of junction of the adjacent horns of the Vs there is a slight antero-posterior extension, forming a median buttress of the inner side of the crown as in *Anchitherium*. The posterior horn of the posterior V is also incurved, as in that genus. The angles of the Vs of the inferior molars are rounded.

The surfaces of the enamel of the teeth of both jaws is smooth.

Measurements.	M.
Length of superior molars, less P-m. I	.046
" of true molar series	.028
" of base of P-m. II	.005

Measurements.		M.
Diameters of base P-m. III	anteroposterior	.006
	transverse	.007
" of base P-m. IV	anteroposterior	.008
	transverse	.010
" of base of M. II	anteroposterior	.011
	transverse	.013
" inferior P-m. III (or IV)	vertical	.005
	anteroposterior	.007
	transverse	.005
Depth of ramus at same tooth		.012
Thickness ramus at succeeding tooth		.009

The *Meniscotherium terrærubræ* differs from the *M. chamense* in two features. The first is its superior size. The second is the flattened form of the external faces of the true molars and the absence of the convexity of the external bases of the crown.

My specimen of this species is from the red Eocene bed in Northwestern New Mexico, from the true Wasatch horizon, or higher than that which produced the other species here described. It was found by my assistant, D. Baldwin.

Remarks.

As stated in my report to Lieut. Wheeler in 1877, no vertebrate remains had been found in the Puerco beds, which underlie the Wasatch in New Mexico, up to that time. It was therefore uncertain whether they form the top of the Cretaceous or the bottom of the Tertiary series. I have recently obtained evidence of the existence of *Champsosaurus* in them, so that their position might be supposed to be in the Postcretaceous system.

It is however quite possible that the species of Mammalia described in this paper were derived from the Puerco Formation. Their horizon is below the Wasatch, and they represent a different fauna from that of those beds.

Attention has already been directed to this fauna in the pages of the *American Naturalist.** I have recorded the presence of the Creodont genera, *Periptychus, Triisodon* and *Deltatherium,* and of the saurian *Champsosaurus.* I have now added the genera *Hyracotherium* and *Meniscotherium,* and a number of new forms of considerable interest. These are the Creodont *Mesonyx,* a new genus allied to *Esthonyx,* and a series of genera and species with a suilline type of dentition, but whose affinities are by no means certain. This point cannot be determined until the characters of the feet are known.

The facies of this fauna differs in several points from that of the Wasatch. *Coryphodon* has not yet been discovered in it, and the flesh-eaters are very primitive. The suilloid genera are characteristic.

*April, August and October, 1881.

Stated Meeting, October 7, 1881.

Present, 12 members.

President, FREDERICK FRALEY, in the Chair.

Letters of acknowledgment were received from the Society at Stuttgard (105, 106, List); the R. Danish Society (107, 108, XViii); the Dutch Society at Harlem (105, 106, List); the R. Academy at Amsterdam (106); the Zoological Society at Amsterdam (107, 108, XViii); the Agricultural Society at Lyons (102-106); the R. S. of Edinburg (106); the Geol. Survey of Canada (108); and the University of the City of New York (108.)

Letters of envoy were received from the Hungarian Academy; the Royal Academy and Zoological Society at Amsterdam; the Central Statistical Bureau, Dutch Society and Teyler Foundation at Harlem; and the Natural History Society at Hanover.

A letter requesting a copy of Proceedings No. 92, was received from the Meteorological Institute at Vienna.

A letter respecting the "American Catalogue" was received from Armstrong & Co., N. Y.

Donations for the Library were received from the Asiatic Society of Japan; the Russian, Prussian, Hungarian and Dutch Academies, and the Academies at Rome, Turin and Dijon: the Natural History Societies at Moscow, Hanover and Stuttgard; the Observatory at St. Petersburg; the Geographical, Anthropological and Zoological Societies and Geological Institute, in Vienna; the German Geological Society in Berlin; the Statistical Bureau at Harlem; the Zoological Society at Amsterdam; the Entomological Society and Statistical Bureau at Brussels; the Geological Committee of Italy; the Guimet Museum and Agricultural Society at Lyons; the Geographical Society and Society of Sciences at Bordeaux; the Anthropological, Ethnographical, Antiquarian Societies, Polytechnic School, and Political and Literary Review, at Paris; the Society at Cherbourg; the Victoria Institute, Meteorological, Geograph-

ical, Geological, Zoological and Asiatic Societies, Nature and the Cobden Club, at London; the Societies at Cambridge, Falmouth, Leeds, Liverpool, and Edinburg; the Mass. Hist. Society; Peabody Museum; the American Antiquarian Society; the American Journal of Science; the American Journal of Pharmacy; the U. S. Department of Agriculture; the National Museum at Mexico; Mr. Eli K. Price, and Mr. F. Fraley.

The death of Captain Carlile P. Patterson, Superintendent of the Coast and Geodetic Surveys of the United States, was announced by Mr. Fraley.

Resolved, That Mr. Robert Patterson be requested to prepare an obituary notice of the late Mr. William E. Dubois.

Communications were received entitled:—

"Notes on the Coal Field Near Cañon City;" and "Notes on the Quinnimont Coal Group in Mercer Co. W. Va. and Tazewell Co. Va. by John J. Stevenson, Professor of Geology in the University of the City of New York."

Professor Cope exhibited a recently discovered lower jaw of *Triisodon quiverensis* from New Mexico, in an almost perfect condition, with four molars and two premolars of marsupial type. Beneath the premolars are exhibited (by fracture) two perfectly formed successional teeth of carnivorous type. He explained the systematic importance of the fact.

Mr. Lesley, remarked that he thought it had importance also in the transcendental discussion of the development theory; since it represented the form-force of this individual creature as performing its functions of bodily creation under the inspiration of two form-ideas or type-principles at the same time and not in the succession of time. And if this be true of an individual form-force, it supposes the same to be true of the form-force of the world at large.

If in a single jaw we see the process of realizing two distinct organic types at the same moment—the alleged older type not producing the alleged later type by natural generation; nor even preparing for its appearance on the scene—and if we see the two types not separated by any interval of time, and not transcendentally transmuted one into the other through intermediate gradations of type form—then, there is no necessity for seeking any other cause for such intervals or graduations, when apparent in the geological record, except the intelligence of the universal form-force in nature, whatever that may be.

In other words, no theory of natural selection can be used to account

for the presence of a wolf's tooth beneath an opossum's tooth in the same jaw. The creative energy in this case is neither governed by memory, nor by present necessity; but is intelligently prophetic of future emergencies. And that is precisely our simplest definition of *divine providence.* But it is also our simplest definition of *practical invention.* Combining the two, we get the view taken by Mr. Agassiz, instead of the view taken by Mr. Darwin.

Professor Cope exhibited also a very interesting tooth, which he named *Ptilodus mediævus*, from the Lower Eocene of New Mexico.

The importance of this discovery lies in the fact that it furnishes an intermediate link between the *Plagiaulax* of the Jura and the recent Australian *Hypsiprymnus*; which two instances of the general type have hitherto remained separated from each other by the whole Cretaceous and Tertiary interval.

Pending nominations, Nos. 934 to 945 were read.

The expediency of printing certain communications was referred for consideration to the Finance Committee.

On motion of Mr. Fraley, it was

Resolved, That the Society most earnestly recommends the appointment of Mr. J. E. Hilgard, as Superintendent of the Coast and Geodetic Surveys of the United States, believing him to be most eminently fitted for the discharge of the duties of the office, by his long and faithful services in conducting said surveys, and by his skill, ability, and full knowledge of all that is required to make said surveys honorable to the Government and useful to the people.

And the meeting was adjourned.

Notes on the Quinnimont Coal Group in Mercer Co. of West Virginia and Tazewell Co. of Virginia. By John J. Stevenson, Professor of Geology in the University of the City of New York.

(Read before the American Philosophical Society, Oct. 7, 1881.)

Bluestone creek, formed at the easterly edge of Tazewell county, Virginia, by the union of Laurel and Mud forks, flows across Mercer and Summers counties of West Virginia to the New river, which it reaches at about four miles south from Hinton, a station on the Chesapeake and Ohio railroad. It receives tributaries from the north, known as Little Bluestone, Mountain, Camp, Wolf, Wide Mouth, Flippon and Simmons creeks. The first four of these rise in an elevated ridge, known as Flat Top, which

separates the waters of Bluestone from those of the Guyandot. But beyond the head of Wolf creek, the streams rise in a narrow ridge, from whose opposite side flow those streams which form the Tug fork of Sandy river. This is a mere knife-edge, so narrow at times as barely to afford room for the country road, which follows its crest.

The surface features of the region on both sides of Bluestone and beyond the divide westward are due wholly to erosion. The carving is stupendous. Standing on any of the high points of Flat Top mountain and looking into Mercer county on the one side or into McDowell and Wyoming on the other, one can compare the surface only to that of an ocean petrified at the height of a terrible storm. But this comparison fails. Narrow ridges, rising to a height of 900 to 1400 feet, separate equally narrow valleys, in which flow rapid streams, carrying much water during a great part of the year. The slopes of these ridges are abrupt, sometimes reaching 35°, and are covered by a dense forest of white oak and poplar (tulip-tree).

The whole region is known as "Flat Top." All the summits between Flat Top mountain and Peters mountain have been planed off to a rudely level surface, a condition wholly independent of the dip, which north from Bluestone varies from 7° to a mere fraction of a degree. Beautifully perfect benches were seen at from 400 to 900 feet above Bluestone creek, in the ridges separating tributaries to that stream, while still higher benches were observed on Flat Top mountain. But as no spirit-level determinations were at hand along Bluestone, no notes were taken respecting the relations of these benches.

The influence of the Abb's Valley fault* is shown along the line of Bluestone, for there the dips are well marked, whereas as one goes northward from that stream, they become insignificant.

Along the New river at Hinton, a fine-grained, grit-like sandstone occurs, which belongs to the Mountain Limestone division of the Lower Carboniferous. It forms a cliff at numerous localities on the Chesapeake and Ohio railroad, both above and below Hinton, and can be traced along New river to the mouth of Bluestone, as well as up that stream to the mouth of Little Bluestone. Higher members of the group appear as one ascends the stream, and the Quinnimont coal group is reached before one comes to the junction of Laurel and Mud creeks, in Tazewell county of Virginia. The top of this group is not caught within the region visited, which extends only to four miles above the mouth of Laurel creek.

A section was obtained on Laurel creek, which does not reach the bottom of the Quinnimont group, but it embraces all of the important beds of the series. It is as follows:

1. Concealed.................................... 70′
2. Sandstone.................................... 10′
3. Drab Shale.................................... 20′
4. *Purdue Coal bed*.................................... 2′
5. Sandstone.................................... 20′

* Described by Prof. J. P. Lesley, Proc. Amer. Phil. Soc., 1872.

6.	Concealed	45′
7.	Sandstone	10′
8.	Shale	0′ 6″
9.	*St. Clair Coal bed*	2′
10.	Sandstone	55′
11.	*Reed Coal bed*	3′
12.	Sandstone	45′
13.	*Tabor Coal bed*	3′
14.	Sandstone	30′
15.	*Coal Branch Coal bed*	9′
16.	Sandstone	70′
17.	*Nelson Coal bed*	11′
18.	Sandstone and Shale	36′
19.	*Coal bed*	1′ 6″
20.	Shale and Sandstone	34′
21.	*Coal bed*	1′
22.	Sandstone	23′
23.	*Coal bed*	Blossom.

The section begins in McDowell county of West Virginia, on the divide separating Bluestone from Tug fork of Sandy river. It was obtained by examinations along Coal branch, Sluss' branch and Haines' Cabin branch, all entering Laurel creek, as well as upon the Tazewell and McDowell road and along Laurel creek itself. Laurel creek flows almost eastward and the head of Haines' Cabin branch is at 7 miles from the mouth of the creek. The top of the section was reached at the head of Haines' Cabin branch and of one fork of Coal branch. The highest beds are not shown, no coal blossom appears in the ploughed fields and only fragments of shale and sandstone are found in the débris covering them.

The blossom of the *Purdue coal bed* was seen on the Tazewell and McDowell road, very near the line between these counties. It was fully exposed near the same road in making an excavation for a spring-house on the Purdue property, where it is said to be 4 feet thick, but the exposure is insignificant now. A very good exposure was found near the head of one fork of Coal branch, at a watering trough on W. L. Reed's land, where very nearly 2 feet of coal are shown. The bed is said to be 4 feet thick in an adjacent hollow, but an exposure near Mr. Reed's house indicates a thickness of not more than 15 inches. The same bed was seen near the Reed school-house on another fork of Coal branch, and at Mr. J. Bailey's house at the head of Haines' cabin branch. It is unimportant at all the exposures observed. The rocks overlying it are shown only on W. L. Reed's property. The massive sandstone, No. 5, is persistent and everywhere marks the place of the *Purdue coal bed*. It is well shown at many places on both sides of the divide.

The interval between the *Purdue* and *St. Clair coal beds* varies from 73 to 80 feet, the former having been found on Haines' Cabin branch, and the latter on Coal branch. The exposure is not complete at any locality visited,

and the character of the rocks filling the interval, No. 6, was not ascertained.

The *St. Clair coal bed* was seen on Coal branch, Haines' Cabin branch and near the head of Sluss' branch, but no full exposure of the bed was found. It was opened at one time on the J. Bailey property near the head of Haines' Cabin branch, where it is said to have somewhat more than 4 feet of coal; but the opening is wholly filled up and only a few fragments of coal remain to show its place. Distinct blossoms were seen at many places near the divide, but none of them indicates a thickness of more than 18 inches. On the St. Clair property near Coal branch, the bed was fully exposed in an excavation for a spring-house and the thickness is said to be 2 feet. But only 19 inches were exposed at the time of examination.

The interval between the *St. Clair and Reed coal beds* is fairly well exposed on a stream leading from the St. Clair house to Coal branch, and contains little aside from sandstone, which varies from massive to more or less flaggy.

The *Reed coal bed* was found only on the waters of Sluss' branch and on the Tazewell and McDowell road. Its place is concealed at all other localities examined. The first exposure is on W. L. Reed's property on a fork of Sluss' branch, where 15 inches of coal are shown in the stream-bed, roofed by 10 inches of shale, underlying sandstone. The coal is prismatic in structure, rather soft, and contains a good deal of pyrites. An exposure on the same property, but on another fork of the stream, shows 2 feet 6 inches of coal, separated from the underlying sandstone by a few inches of clay. The blossom of the bed is shown on the Tazewell and McDowell road, which crosses it at barely a mile from the Nelson coal-pit.

No continuous exposure of the interval to the *Tabor coal bed* was found, but the whole of it was seen. It is occupied by sandstone almost unbroken by shale. The rock is comparatively fine-grained and shows no pebbles.

The *Tabor coal bed* was seen only on Sluss' branch, its horizon being concealed at all other localities examined. The exposures on Sluss' creek are imperfect, there being no opening in the bed. It was opened at one time on Mr. Tabor's property, but the opening has fallen in and only 1 foot of coal is shown. For 6 inches on top it is hard and bony, but below that, the coal as far as seen is good. The same bed is exposed on another fork of Sluss' branch, on W. L. Reed's property, where 3 feet of good coal were seen.

The *Coal Branch coal bed* is best shown on Coal branch at a few yards below the St. Clair crossing, but it is evidently the bed which was once opened on Elkanah Reed's property at the head of one fork of that branch; it was opened at one time in the bluff overlooking Laurel creek above Mr. Nelson's house, and its blossom is fairly shown in the Tazewell and McDowell road, at a little way from Laurel creek. Six feet of coal are exposed by a little run emptying into Coal branch near the St. Clair crossing, where 4 feet of shale separate the coal from the overlying sand-

stone. For 5 feet the coal is soft and clean, but below that is one foot of hard coal which seems to be quite bony. A blossom in the bank of the stream, and 15 feet above the water's edge, was stripped off and showed about 9 feet of coal, but the character and structure of the bed could not be ascertained. Samples for analysis were taken from the exposure in the run, an effort being made to obtain a section of the 5 feet there shown. As analyzed by Mr. A. S. McCreath, the coal has :

Water	1.225
Volatile combustible matter	21.435
Fixed carbon	74.603
Sulphur	0.435
Ash	2.302

It is a coking coal, altogether too soft for shipping. The coke should be of exceptional purity, but the amount of volatile matter is so small as to make the strength somewhat doubtful. No full exposure of this bed was seen on Laurel creek, but at the old opening near Nelson's, on that creek, the thickness is said to be about 6 feet. The bed is nearly 90 feet above Laurel creek at the mouth of Coal branch.

The interval between the *Coal branch* and *Nelson* coal beds is occupied by a more or less flaggy sandstone which forms bold cliffs along Laurel creek and Coal branch. It was not followed above the mouth of that branch. The upper bed rests almost directly on this sandstone and only a few feet of shale separate the cliff from the lower bed.

The *Nelson coal bed* is reached on the Tazewell and McDowell road as one approaches Laurel creek. There, at say one mile above the mouth of Laurel creek, Mr. Nelson has made an opening which has been pushed to about 25 feet. The working does not take in the whole bed, and the exposure at the mouth of the pit is such as to render measurement difficult. As nearly as could be made out, the structure of the bed is as follows :

1. *Coal*	5′ 4″
2. Bone	0′ 2″
3. *Coal*	0′ 6″
4. Bone	0′ 2″
5. *Coal*	2′ 10″
6. Clay	0′ 6″
7. *Coal*	1′ 0″
	10′ 6″

Nos. 6 and 7 were not seen in detail, and the thicknesses are given according to Mr. Nelson's statement, these parts of the bed having been well exposed at an opening which he had abandoned.

The total thickness of the mined portion is about 7 feet, but there would be no difficulty in taking out fully 8 feet, as only a thin slab of coal need be left to strengthen the roof. Of the part above No. 6, the whole, excepting the two layers of bone, is good, the coal between these being nearly

equal to that of Nos. 1 and 5. The main body, No. 1, is brilliant, but shows many binders of mineral charcoal and an occasional pocket of the same material. No. 5 is not so brilliant as No. 1. The coal throughout the bed is prismatic and very soft, altogether too tender for chipping, but it cokes very readily. Samples from Nos. 1 and 5 were sent to Mr. A. S. McCreath for analysis. He reports the composition as follows:

Water	0.820
Volatile combustible matter	20.580
Fixed carbon	76.182
Sulphur	0.388
Ash	2.030

The only defect of the coal in No. 3, is that it contains some sulphur. This coal should yield a remarkably pure coke, though one not able to bear the burden of a high stack.

No other opening was seen along Laurel creek, but the bed can be followed without difficulty by means of the overlying sandstone down Laurel creek, and thence along Bluestone, but no estimate respecting it can be made from the imperfect exposures. An opening was worked at one time on Laurel creek above Nelson's, but it has been abandoned. There the total thickness is said to be about 11 feet. By means of the overlying sandstone, the bed was followed up the creek to the mouth of Coal branch, above which it soon goes under the stream, which in passing over it forms rapids, whereby the thickness is made to appear very great. The coal is shown for a short distance up Coal branch.

Only the blossom of *Coal bed*, No. 19, was seen. It has been ploughed up on Mr. Nelson's farm, and found to be 1 foot 6 inches thick. Its blossom is shown in a run entering at a little way above Nelson's house. It was not seen elsewhere. No. 21 is in the spring near the house, its only exposure as far as seen. No. 23 was not observed. It is said to be present in the bed of Laurel creek at about 300 yards below Nelson's house.

The dip is nearly 2 degrees at Nelson's pit, but soon becomes very gentle as one recedes from the influence of the Abb's Valley fault. Along Laurel creek the dip is insignificant.

On Simmons' creek, Mr. George Belcher has opened a coal bed at two places. The following measurement was made on his property:

1. St Clair coal bed	Blossom.
2. Sandstone	20′
3. Concealed	50′
4. Sandstone	35′
5. *Tabor coal bed*	4′

No. 1 is exposed imperfectly in the road near Mr. Belcher's house, but it has been ploughed up in an adjoining field, where its thickness is said to be somewhat more than 1 foot. The *Purdue coal bed* has been ploughed up near Mr. Belcher's barn, but its thickness was not ascertained. No ex-

posure occurs in the interval No. 3, in which the *Reed coal bed* belongs. At the upper opening in No. 5, the bed is now exposed to a thickness of 2 feet 6 inches, but it is said to be 3 feet 6 inches. The coal is harder than that of any bed fully seen on Laurel creek, but it is broken by many thin partings or binders, mostly of mineral charcoal. Sulphur is present in the top 10 inches, but below that the quantity is insignificant, and the coal is an excellent fuel. The bed is four feet thick at the other opening, and the bottom seems not to have been reached. A large bed, probably the *Nelson,* is said to be exposed at some distance further down the creek, but it was not examined.

A section was worked out hastily on Camp creek, beginning at the crest of Flat-top mountain. It is as follows:

1.	Concealed	60′
2.	Ferruginous sandstone	0′ 10″
3.	Concealed	37′
4.	Yellow sandy shale	6′
5.	*Coal bed*	Blossom.
6.	Clay	1′
7.	Yellow sandy shale	31′
8.	*Purdue coal bed?*	1′ 6″
9.	Clay and variegated shale	15′
10.	Sandstone	30′
11.	Concealed	65′
12.	*St. Clair coal bed* seen	1′ 6″
13.	Sandstone	90′
14.	Shale with *Tabor coal bed*	1′
15.	Sandstone or sandy shale	20′
16.	Concealed, said to contain a *coal bed*	30′
17.	Sandstone and some shale	40′
18.	*Nelson coal bed,* seen	3′
19.	Concealed	10′
20.	Sandstone	25′
21.	Shale and shaly sandstone	30′
22.	Carbonaceous shale	0′ 3″
23.	Shale	16′
24.	*Coal bed*	Blossom.
25.	Imperfect exposure	55′
26.	Sandstone	30′
27.	Shales and sandstone, imperfectly exposed	100′
28.	Sandstone	50′
29.	Sandstones and shales	400′

Ending where the trail leading to Wolf creek crosses Camp creek, at a mile and a half above its mouth. This gives very nearly 600 feet of coal-bearing strata on Camp creek, the rocks below No. 26 being regarded as belonging to the Lower Carboniferous. No calculation for the dip was

made and a closer examination would doubtless lead to a moderate change in the thickness of several of the intervals.

The only coal beds which have been opened are Nos. 8, 12 and 18, but none of these was in shape for measurement at the time of examination. No. 12 is exposed in the bed of the run, and its thickness is said to be nearly 3 feet. The coal is clean, free from pyrites and slates, is soft and should yield a good coke. No. 18 was mined for local use at the junction of the forks of Camp creek. Its thickness is said to be 4 feet 2 inches. The coal is soft, clean and is admirably fitted for blacksmiths' use. No. 24 was once exposed near the creek at half a mile below Reed's mill. The thickness is said to be 3 feet.

The following section of the Lower Carboniferous rocks was obtained in passing from Little Bluestone to Mountain creek :

1.	Conglomerate	20′
2.	Imperfectly exposed	110′
3.	Yellow shaly sandstone	45′
4.	Concealed	25′
5.	Gray to yellow shaly sandstone	80′
6.	Imperfectly exposed	85′
7.	Conglomerate	10′
8.	Concealed	225′
9.	Limestone	8′
10.	Imperfectly exposed	370′
		978′

Exposures of dark red shales occur frequently in the intervals 2, 6 and 10, and No. 10 is made up almost wholly of such shales. This section brings one to the sandstone which forms the river bluffs in the vicinity of Hinton.

Notes on the Coal-field near Cañon City, Colorado. By *John J. Stevenson, Prof. of Geology in the University of New York.*

(Read before the American Philosophical Society, October 7, 1881.)

A small area of Laramie rocks lying along the easterly foot of the Greenhorn mountains has escaped erosion. Its shape is irregular and its breadth varies from two to five miles, being greatest at little more than midway north and south. The total area is not far from 70 square miles.

This little field, which has attained much economical importance, owing to the excellence of the coal from one of the beds, is deeply trenched by several streams which flow across it in cañons with walls from 200 to 500 feet high. The more important of these, beginning at the north, are Alkali gap, Chandler creek, Oak creek, Coal creek and Newland creek. Examinations more or less detailed were made in all except that of Newland creek.

The strike is almost north and south. The dip on the eastern side is gentle, varying from 3 to 6 degrees, and that side of the trough is the longer one. The axis of the synclinal is distinct, passing at about two miles from the eastern outcrop. The dip quickly becomes abrupt on the western side, being first 7, then 10, then 15 and at last 40 degrees where the outcrop is first reached on Oak creek, but the outcrop lies further west both north and south from Oak creek and the dip becomes sharper and sharper until at last the beds are perpendicular or even pushed over.

The following generalized section of the field was made out; but as no opportunity was afforded to revise the work, it may be defective in some of its details:

1.	Sandstones, with some thin shale, not examined in detail	400′
2.	Sandstone, buff, with occasional pockets of shale	45′
3.	*Coal bed* M	Blossom.
4.	Shale and sandstone	165′
5.	Variegated shale	170′
6.	*Coal bed* L	4′ 2″
7.	Shale	14′
8.	*Coal bed* K	0′ 6″
9.	Sandstone	25′
10.	Variegated shale	30′
11.	*Coal bed* J	1′
12.	Shale	24′
13.	*Coal bed* I	3′
14.	Sandstone	120′
15.	Shale and sandstone	25′
16.	*Coal bed* H	5′ 3″ to 9″
17.	Sandstone and shale	46′
18.	*Coal bed* G	1′ 10″ to 2′
19.	Sandstone and shale	30′
20.	*Coal bed* F	4′ 6″ to 0″
21.	Shale	11′
22.	*Coal bed* E	1′ 8″ to 6″
23.	Variegated shale	30′
24.	*Coal bed* D	1′ 10″ to 1′ 3″
25.	Shale and sandstone	25′
26.	*Coal bed* C	4′ 6″ to 6″
27.	Sandstone and shale	50′
28.	*Coal bed* B	4′ to 6″
29.	Shale	30′ to 20′
30.	*Coal bed* A	6′ to 10″
31.	Shale	10′
32.	Sandstone	70′ to 100′

The same difficulty was experienced here as in the *Trinidad coal field,*

further south. Limestones are absent and the sandstones show abrupt changes in composition. Direct tracing around the points of bluffs is not always practicable, and identifications of coal beds in different cañons are based largely on the intervals found in the typical section obtained on Oak creek. As these intervals are by no means constant, some of the identifications may prove to be erroneous.

The eastern outcrop of the field is well marked by bluffs and it cannot be mistaken, except in the extreme northern part, where erosion has carried away the lower beds and the bluffs contain only the higher members of the series. The sharp hogbacks in which the beds are turned up at angles varying from 40 to 90 degrees, mark the western limit sufficiently well, except in the southern part of the field where erosion has beveled off the surface of the mesa. But even there, exposures are found on the larger streams which enable one to follow out the limit with but little difficulty.

Coal mines have been opened at several localities along the eastern side of the trough and branch roads have been constructed by the Atchison, Topeka and Santa Fé and the Denver and Rio Grande railroad companies, leading to mines owned or controlled by those companies. Insignificant openings only were seen along the western outcrop, but some pits on the northern side of the field have been worked somewhat extensively to supply Cañon City.

Exposures are infrequent on the northern edge of the field, where a deep covering of gravel conceals all the rocks even to the tops of the hills; while beyond the sharp ridge bounding the field, a basin has been eroded and rocks are rarely seen in place. The few openings seen afforded no data for determining the position of the beds in which they have been made. A similar difficulty was encountered on the north-eastern side of the basin where the lower beds of the series are buried under the alluvial coating of the plain, and only the higher beds are shown in the bluffs. Some *coal* blossoms and an extensive opening were seen here, but their position was not determined, further than they belong to the upper part of the section.

Alkali Gap. The stage-road leading from Cañon City to Silver Cliff passes through this gap at about 4 miles from Cañon City. The exposures are excellent for a distance of nearly 400 yards, but as soon as one enters the basin into which the gap opens, all exposures cease. The following section was obtained in this gap, the thicknesses of the several beds being determined by pacing and calculation from the dip:

1. Conglomerate	239′
2. Sandstone	168′
3. Concealed	40′
4. Sandstone	128′
5. Shale	3′
6. Sandstone	69′
7. Concealed	42′

8.	Sandstone	6′
9.	Concealed	122′
10.	Sandstone	10′
11.	Concealed	12′
12.	Sandstone	8′
13.	*Coal bed*	5′
14.	Sandstone	6′
15.	Concealed	20′
17.	Shale	5′
18.	*Coal bed*	2′
19.	Imperfectly exposed, much whitish sandstone	75′
20.	Sandstone	10′
21.	Concealed	160′
22.	*Coal bed*	3′ 2″
23.	Clay	1′
24.	Sandstone	30′

With this all exposures cease along the line examined, but Mr. Alex. Bowie, local superintendent of the coal mines at Rockvale on Oak creek, states that another bed of *coal* has been seen by him below the sandstone. Unfortunately no determination of the distance was made by him.

The conglomerate at the top of the section is very coarse and altogether unlike any rock seen elsewhere in the field. If Mr. Bowie's observations be accurate, this rock is higher in the series than any exposed in the typical section obtained on Oak creek and it has been eroded from the mesas in the southern part of the field, from Chandler creek southward. The sandstones down to No. 12 are soft, with a yellowish tint and readily disintegrate when exposed to the weather. Thin beds of shale occur here and there in the upper part, but are not persistent and they have been ignored in making up the section.

The *Coal bed*, No. 13, is exposed at the roadside as one enters the gap from the west. Its dip is 85 degrees at the top of the shaft and 75 degrees at the bottom. No detailed measurement was made as the shaft has been abandoned and the edge is unsafe. The bed shows five benches of *coal*, with a layer of dark shale fully 5 inches thick. A parting of sandy clay, nearly 2 inches thick, appears to be persistent. *Coal bed*, No. 18, has been opened by a shaft probably 20 feet deep. The dip is irregular but is somewhat more than 75 degrees. The *coal* so far as exposed is friable and worthless. No bed was seen between this and No. 24, but Mr. Bowie states that another bed exists in this interval and that it is shown at a little way from the line followed. It is 1 foot 7 inches thick and contains very fair coal. No. 22 dips at 85 degrees, almost due east; it is in four benches, separated by thin partings of sandy shale. It has been opened by two shafts, each about 20 feet deep; but the coal as far as seen is badly broken by exposure to the weather.

In the absence of detailed measurements below the bed, No. 22, one may not undertake to identify these beds with any in the Oak creek section;

but it may be that they represent *Coal beds* C, I and L. The associations of the lowest bed suggest reference of it to *bed* C.

Chandler creek. The cañon of this stream crosses the field and affords very fair exposures of the upper part of the section ; but erosion has been active at both ends of the cañon, so that the lower beds have been removed and for the most part they are now buried under gravel on the broad elevated terrace. A boring made at the mouth of the cañon, at a little way east from the foot of the bluffs, begins in sandstone, No. 14 of the general section, and continues to the depth of 301 feet 9 inches. The record of the boring as furnished by Mr. Alex. Bowie, is as follows :

1. Gravel	30′	6″
2. Sandstone	40′	
3. Shale	7′	6″
4. Sandstone	1′	4″
5. Shale	6′	10″
6. *Coal bed*	4′	1″
7. Hard sandstone	3′	9″
8. Soapstone	52′	
9. Sandstone	6′	
10. Soapstone	58′	4″
11. Sandstone	5′	4″
12. Shale	48′	2″
13. *Coal bed*	5′	5″
14. Soapstone	8′	9′
15. Sandstone	2′	
16. Soapstone	1′	4″
17. Sandstone	6′	
18. Sandstone and shale	14′	5″

The upper bed seems without doubt to be *Coal bed* H, though it is much thicker here than at any other locality examined. The structure as shown in the boring is :

Coal, 1′ 3″ ; clay, 11″ ; *coal*, 1′ 11″.

The lower bed is usually thought to be the same with *Coal bed* A, the bed mined on Coal creek by the Colorado Coal and Iron Company, but the interval to the upper coal is very nearly the same with that obtained between *Coal beds* H and C on Oak creek, barely a mile away ; so that the lower bed is more probably *Coal bed* C, the bed worked in shaft No. 2 of the Cañon Coal Company. Its structure as shown in the boring is :

Coal, 3′ 4″ ; clay, 11″ ; *coal*, 1′ 2″.

A number of borings have been made along Chandler creek, but the records are not accessible. The trough becomes deep in this cañon, and at the bottom of the synclinal, *Coal bed* A is fully 800 feet below the surface. The walls of the cañon are low and the cañon itself is very broad, especially near the line of the axis. No trace of the great conglomerate of Alkali gap was observed here.

Beyond the axis of the synclinal, the rocks rise rapidly westward and at the head of the cañon one is brought very near to the horizon of *Coal bed* H. An opening has been made in a bed at a little way beyond the head of the cañon, but in the absence of all exposures near at hand, the place of the bed could not be determined. The lowest sandstone of the group is reached at a short distance beyond and shows the same features as those to be described on Oak creek. The middle Cretaceous rocks lie immediately behind the great sandstone and continue thence to the foot of the mountain, where the Dakota rests on the metamorphic rocks. The transition from the Coal group to the Fort Pierre is very gradual and no line of separation can be found.

Oak creek. The cañon of this stream follows a north easterly direction across the field and affords by far the best series of exposures. It is followed by the Coal branch of the Atchison, Topeka and Santa Fé railroad to Rockvale, where the Cañon Coal Company has sunk the shaft, No. 1, with the view of working *Coal bed* A. The outcrop of that bed is poorly shown in this cañon along the eastern side of the field, but that of *Coal bed* C is frequently exposed. Shaft No. 2 of the Cañon Coal Company opened this bed and a slope is under way to reach the same bed for the Colorado Coal and Iron Company. The section at shaft No. 2, including the measurements in the shaft, is as follows :

1. Sandstone, seen on the bluff	13'
2. Shales	10
3. Concealed to curb of shaft as estimated from the dip	120
4. Clay and gravel in shaft	30'
5. Shale and thin sandstone	31'
6. *Coal bed* E	1' 6"
7. Shale and thin sandstones	47' 6"
8. *Coal bed* C	4' 6"
9. Fireclay	0' 3"

A coal blossom, indicating a thickness of about 8 inches, was seen at a few rods east from the shaft. Allowing for the dip, this bed belongs near the middle of the gravel at the top of the shaft, and is therefore *Coal bed* G. *Coal bed* E contains very good coal, but as it is not of workable thickness, no tests have been made to determine its value. *Coal bed* C is mined in the shaft where its structure is

Coal, 2' 2"; clay, 2"; *coal*, 1' 9" to 2' 2".

An outcrop on the opposite side of the valley shows the bed 3 feet 10 inches thick, as reported by the local superintendent of the company, and there the parting is present also. But lower down the stream the bed becomes very thin and at several exposures it is insignificant. In the shaft it yields an excellent coal, which is hard, must be blasted but comes out in large blocks. The underlying fireclay aids much in mining, but it is soft and is likely to be a source of annoyance in the immediate vicinity of the shaft. The dip is a little south of west at 5 degrees.

The sandstone, No. 1 of the section, caps the bluff directly north from the shaft and is easily followed to Rockvale, where it is alongside of the railroad. The Cañon City Coal Company's shaft No. 1 begins in this rock. A boring was made in creek bottom at about 500 feet from the shaft and it begins in this rock, though somewhat higher than the top of the shaft. The record of the boring is

1.	Sandstone	82′	
2.	Shale	17′	
3.	White sandstone	7′	3″
4.	*Coal bed* H	0′	9″
5.	Sandstone	10′	3″
6.	Soft shale	4′	
7.	Sandy shale	31′	4″
8.	*Coal bed* G	1′	4″
9.	Sandstone, hard	15′	5″
10.	Argillaceous shale	3′	8″
11.	Sandy shale	18′	
12.	*Coal bed* E	0′	6″
13.	Sandstones and shales in thin beds	52′	8″
14.	Black shale	5′	4″
15.	Sandstone	2′	
16.	*Coal bed* C	0′	8″
17.	Sandstone and shale	3′	7″
18.	Black shale	21′	8″
19.	Sandstones and shales	20′	10″
20.	*Coal bed* B	0′	6″
21.	Black shale	23′	1″
22.	*Coal bed* A	3′	4″
23.	Arenaceous shale	9′	7″
24.	Black shale	5′	
25.	Sandstone and sandy shale	5′	1″
	Total	341′	6″

The company's shaft at the time of examination was down 220 feet. *Coal beds* G and H are thicker in the shaft than in the boring, the former being 1 foot 2 inches and the latter 1 foot 10 inches. The great sandstone, No. 1 of the section, is nearly 120 feet thick. It varies somewhat in structure, as is well shown in the railroad cut at Rockvale. In the boring it seems to be a compact sandstone throughout and it shows a similar structure in the shaft, but in the railroad cut, only a few yards from the shaft it becomes shaly toward the middle, there being not less than 20 feet of shale exposed in the cut. The rock is mostly massive, soft and reddish-yellow to buff and bluish gray. It contains vast numbers of *Halymenites major*, of which excellent specimens can be obtained at Rockvale. This fossil is most abundant in the upper part of the rock.

The bluff immediately north from the shaft at Rockvale affords good exposures of the overlying beds. The section obtained on this bluff is as follows:

1. Sandstone.. 20′
   This is buff, soft, weathering with honeycombed surface, but contains a hard reddish band, only a few inches thick.
2. Sandstone.. 45′
   Very like the last, but containing some shale, which decreases westward until both sandstones are practically one.
3. *Coal bed* M.. Blossom.
   This may be only a carbonaceous shale.
4. Shales and sandstone.. 61′
   Where the section was taken this seems to be almost wholly variegated shale, but within 50 yards it has a bed of massive sandstone, buff or yellow, soft and covered with a thin band of hard red sandstone.
5. Sandstone.. 8′
   Yellow, where examined, more or less ferruginous, with small nodules of carbonate of iron; at a little distance further up the creek, it becomes buff like the higher beds and weathers into rounded bosses. This is a marked and persistent bed, which remains above the surface to the bottom of the synclinal at the forks of the creek. It has on top a thin bed of flaggy red sandstone, which is very hard.
6. Shale.. 87′
   Variegated, with some thin beds of sandstone, 1′ to 2′ thick, which are more or less argillaceous; here and there is a band of carbonaceous shale; possibly some coal may belong in this interval but none was recognized.
7. Sandstone.. 9′
   Very like No. 5.
8. Shales.. 186′

10.	Variegated shales	30′
11.	*Coal bed* J	0′ 10′
	Represented only by carbonaceous shale, where the section was measured; but it has been opened elsewhere on the bluff, with a thickness of 1′.	
12.	Shale	24′
	At the base of this is a very friable sandstone, almost white, which is persistent.	
13.	Concealed	25′
	This is calculated from the dip as the interval between the base of No. 12 and the top of the sandstone in which the shaft begins. Exposures in the vicinity indicate that this is occupied in part at least by shales at the base of which is *Coal bed* I. That bed is not exposed here.	

This bluff is continuous to the cañon of Chandler creek, and the same section is exposed at the mouth of that cañon. The sandstones of the section are all light yellow or buff, and almost without exception have a band of hard red flaggy sandstone as the top layer. Search was made in all these red beds, but no fossils were found aside from the *Halymenites*, and that has its upper limit in the great sandstone at the top of the shaft. Occasional impressions of fossil dicotyledonous leaves were seen, and a fine *Sabal* has been brought out of the shaft No. 1. The dip here is somewhat more than 3 degrees and almost due west.

South Oak creek enters the main stream at Rockvale and flows northwardly. The great sandstone with *Halymenites* continues in sight along this stream for nearly two miles. At the first fork of the stream the top of that rock is reached, and there *Coal bed* I is well exposed, with the following structure:

1. *Coal*	8½″	
2. Clay	½″	to 1″
3. *Coal*	9½″	
4. Sandy clay	1″	to 1½″
5. *Coaly* shale	2″	to 4″
6. *Coal*	11″	to 13″
Total		2′ 11″

The coal is evidently poor throughout. The bed is overlaid with shales succeeded by the friable white sandstone seen near Rockvale. Streaks of coal are shown in the shale at a little way further up the creek. At say a mile further up the main stream its cañon and that of a gulch leading into Bluff Spring park, a tributary to Coal creek, come very closely together. There the shales, No. 8 of the Rockvale bluff, are reached, but no exposure of *Coal beds* K and L was found.

Following up Oak creek above Rockvale, one sees the rocks descending, until the sandstone, No. 5 of the Rockvale section, is the lowest bed ex-

posed. Near the line of the synclinal axis a cañon opens from the north, at whose head is a fine exposure of the higher beds. But there was no opportunity to examine this in detail, and the thickness of the beds overlying the Rockvale section was estimated at 400 feet. They are chiefly buff sandstones, with comparatively thin beds of shale, which vary greatly in thickness and may be regarded only as partings of the sandstone. No traces of coal have been observed in these higher beds. The synclinal axis crosses Oak creek very near the forks of the stream.

A boring was made some time ago by the Colorado Coal and Iron Company on Oak creek, at a little way below the crossing of the synclinal. The curb of the boring is but a few feet under sandstone, No. 5 of the Rockvale section, and *Coal bed* A was reached at 571 feet. The record of the boring is not accessible and the depth is given according to indirect information.

The section to *Coal bed* H is shown in the bluff at the head of Oak creek cañon, and that *coal bed* was opened some years ago, by Mr. Nelson, just south from the cañon; but the opening was abandoned, owing to inferiority of the coal. The condition of the pit when visited was not such as to afford exact measurement. The bed is said to be 5 feet 3 inches thick, with a shale parting near the middle. Drab shales overlie it, separating it from the light gray sandstone, above which, at a few feet, is the great yellow sandstone. When freshly mined, the coal is said to look well, but after short exposure it slakes. The dip at this pit is eastward at nearly 40 degrees.

At nearly a mile further south along the bluff, *Coal bed* I was seen above the yellow sandstone, showing:

Coal	1″
Clay	1′
Coal	1′ 2″

But the crop coal is very poor. Higher up on the hill-side, *Coal bed* K was seen 6 inches thick, while at a few feet higher is *Coal bed* L, showing:

Coal	2′ 6″
Clay	6″
Coal	1′ 3″

The bed makes a formidable blossom, but the exposure does not suffice to indicate the quality of the coal. The great mass of shale, No. 8 of the Rockvale section, contains much friable sandstone here, which breaks down even more readily than the soft clay shales seen further down the the creek. The sandstone, No. 5 of that section, is persistent here and is easily recognized, though it is somewhat harder than at Rockvale.

The outcrop of *Coal bed* A is shown in a low ridge west from the Nelson opening, and the road leading to Mr. Bishop's ranch passes over it. The exposure is imperfect here and the bed is much better shown at a little way further north, where it was opened by Mr. Bassick near the stone cabin. This opening was abandoned because the abrupt dip, more than

40 degrees, made raising the coal by horse-power too difficult for profit. The crushed outcrop at this pit shows a thickness of nearly 20 inches, but the bed is said to show 3 feet of good coal at the end of the slope. The overlying shale is thin and is covered by a yellow sandstone.

A low mound rises in the park between this ridge and the bluff. A *coal* blossom was seen here, but its place was not determined, though the bed is probably C. The blossom indicates not much coal.

Followed southward the yellow sandstone associated with *Coal bed* A is seen forming a sharp low ridge, which continues southward to the head of Oak creek, where it is lost in the mesa. At the head of Oak creek cañon a park intervenes between the bluff and the sandstone ridge; but southward the park becomes narrow and at length the mesa and the low ridge are united. An exposure on Mr. Bishop's ranch, near the point of union, shows the following section:

1. *Coal bed* C?	0′	7″
2. Shale and some sandstone	22′	
3. *Coal bed* B?	0′	2″
4. Shale	36′	
5. *Coal bed* A	3′	10″
6. Shales, sandy, not fully exposed	15′	
7. Deep yellow sandstone, estimated	100′	

The identification of the smaller coals is only provisional, there being no other detailed measurements on this side of the field for comparison. The coal of bed A appears to be by no means bad and the crop coal has a bright fracture. The dip is vertical here and the bed can be followed easily from this place to where it passes into the mesa.

The sandstone below the coal is the lowest bed of the Coal group. The upper part is hard sandstone, honey-combed with films of quartz, and holds thin beds or pockets of conglomerate in which the pebbles vary in size from buckwheat to pea. The color varies from cream to deep reddish yellow, and in most respects the rock is an almost exact duplicate of the Dakota sandstone, which is exposed within a short distance at the foot of the Greenhorn mountains. The lower part of the mass becomes more or less shaly, and at length passes into a series of dull reddish shales, somewhat sandy but mostly argillaceous, and showing little structure. These in their turn pass almost imperceptibly into the Fort Pierre shales, which are well exposed at the head of Oak creek, where they hold the customary septaria and abundance of selenite. The thickness of the dull beds below the sandstone was not measured on Oak creek, but it appears to be not far from 100 feet.

The Niobrara and Fort Benton groups are fairly well shown at the head of the creek and as far down as Mr. Bishop's ranch; but no effort was made to determine their thickness. The Dakota is exposed on a tributary of Oak creek, where it is said to contain a thin bed of fairly *good coal*. This has been opened and the whole space underlaid by the Dakota has been taken up as coal land. The guide was unable to find the opening,

but there seems to be no doubt that it exists and that the coal is there. The upper member of the Dakota shows the usual features, but the lowest member is a coarse conglomerate, 10 or 15 feet thick, which is made up of fragments of the coarse gneissoid granite on which it rests. These fragments have suffered little from water, and the conglomerate can be distinguished only with difficulty from the underlying granite.

No exposures occur on the mesa between Oak creek and South Oak creek, aside from fragmentary exhibitions of sandstones, which barely suffice to indicate the dip, and give no information respecting the succession of the beds.

Coal Creek.—Coal creek is followed by a branch of the Denver and Rio Grande railroad, leading to the mines of the Colorado Coal and Iron Company. One branch of the stream flows northward along the eastern edge of the field, while several tributaries flow to it from the west, each of which has eroded a cañon, exposing a large part of the section. Examinations were made along several of the streams.

At the mines of the Colorado Coal and Iron Company, on Coal creek, the following exposure was found:

1. *Coal bed* C	0′ 8″
2. Shale and sandstone	50′
3. *Coal bed* B	0′ 10″
4. Shale	30′
5. *Coal bed* A	6′ 2″

And the dip is N. 30° W. mag.

Coal bed C, the same with that mined in shaft No. 2 of the Cañon City Coal Company, on Oak creek, is represented here only by a little carbonaceous shale. *Coal bed* B is well shown on the face of the bluff, and descends with the road from the top of the hill. *Coal bed* A is mined extensively and yields a superior coal, which is used in the railroad engines and is shipped largely to be used as fuel at Denver and other cities of Colorado. The bed shows the following structure at the mouth of the slope:

Coal	1′
Clay	7″
Coal	4′ 7″

At half a mile further up this branch of Coal creek, the same bed is mined by the Grand Cañon Coal Company. The bed was not measured here, but the thickness is reported by the President to be 3 feet 6 inches, and the quality is regarded as equal to that of coal from the other mine. Only the lower division of the bed is present in the slope. The upper division is merely a "rider" coal, and the interval between it and the main body varies from zero to 11 feet; the latter interval being seen at the Cassidy slope, while the two divisions are in contact at many places in the Colorado Company's mine. The rider is distinctly shown in the gulch at the Cassidy slope.

Following up the gulch for half a mile, the following section was obtained:

1. Sandstone	15′	
2. Shale	2′	
3. *Coal bed* G	0′	6″
4. Shale and thin sandstone	15′	
5. Sandstone	5′	
6. Black shale	8′	
7. *Coal bed* F	4′	6″
8. Bluish shale	11′	
9. *Coal bed* E	1′	8″
10. Variegated shale	28′	
11. *Coal bed* D	1′	8″
12. Shale and thin sandstone	25′	
13. *Coal bed* C	Blossom.	
14. Sandstone and shale, estimated	45′	
15. *Coal bed* B	1′	2″
16. Shale	16′	
17. *Rider coal bed*	0′	10″

Coal bed B is shown on the low hill alongside of the road, at a few rods above the trestle; it seems to be hard and fairly clean coal. The upper part of the interval, No. 14, is occupied by a massive, soft, yellowish white sandstone, which is about 20 feet thick. *Coal bed* C is represented by carbonaceous shale, which was followed up the gulch to where it passes under the surface. The interval between it and *Coal bed* D was estimated. The rest of the section was obtained on a projecting point opposite a gap in the hill, lying between the road and the gulch. *Coal bed* D is shown on both sides of the stream, but is thicker on the southerly side, where it shows 22 inches of coal.

Coal bed F appears on the bluff, where its blossom measures 4 feet 6 inches, but a good exposure occurs at a few yards further up the gulch, which exhibits the structure of the bed in detail as follows:

Coal	0′	5″
Parting	—	—
Coal	1′	7″
Clay	0′	2″
Coal	0′	9″

The coal is sulphurous and dirty, so that it is of little value. The overlying shale is fissile and very black. *Coal bed* G is exposed under the edge of the sandstone which caps the bluff. This rock is reddish-yellow, mostly massive and occurs in cliffs. The thickness appears to be upwards of 40 feet, but exposures further south show that *Coal bed* H belongs at but a little way above *Coal bed* G, and the thickness of the lower sandstone is not more than 15 feet. The rock above *Coal bed* H is the one form-

ing the top of the mesa, and its cliff is shown at a little way back from the top of the bluff overhanging this gulch.

Crossing the narrow divide to Bluff Spring park, one passes over the great sandstone in descending to the park. The spring issues from almost directly underneath the sandstone, No. 1 of the last section, but *Coal bed* G is not exposed. The sandstone overlying *Coal bed* F caps a little mound in the park, and that *coal bed* has been exposed there with a thickness of 2 feet 6 inches. The overlying shales are not black, the carbonaceous matter having disappeared. The road leading from Bluff Springs park to the Shaw gulch passes under a bluff, immediately beyond the park, where *Coal beds* E and F are exposed. The latter is but 1 foot 6 inches thick, but the former shows:

Coal, 8″; clay, 4″; *coal*, 1′.

The coal is very poor. The shale above *Coal bed* F is brown and yellow, carbonaceous matter being wholly absent. No prospecting has been done in Bluff Spring park below the line of the wagon road, and *Coal bed* A has not been recognized.

The massive yellow sandstone overlying *Coal bed* H is easily followed across the low divide separating Bluff Spring park from the Shaw gulch. In this short gulch, the Cañon Coal Company have mined *Coal bed* F, known as the *Shaw coal*. The coal has been hauled 4 miles in wagons, to be shipped at Rockvale. It underlies a thin gray sandstone and the shales intervening are lead-colored. The structure of the bed as shown in the mine is:

Coal	0′ 7″
Parting	— —
Coal	1′ 5″
Parting	— —
Coal	1′ 4″

The thickness in this mine varies little from 40 inches. The coal is good and has been used extensively on the engines of the Atchison, Topeka and Santa Fé railroad; but the engineers think it inferior to coal from *bed* A.

Coal bed G is found here at 22 feet above F and is insignificant. *Coal bed* H is very thin and but 17 feet above G. The Great sandstone forms a bold cliff here and, according to Mr. Bowie's measurement, it is 75 feet thick, thus showing a decided diminution in thickness southward. *Coal bed* I rests on the sandstone and, where explored immediately north from the Shaw gulch, is 22 inches thick.

The next gulch southward is that known as Bailey's gulch. It is barely half a mile from the Shaw gulch and affords a good exhibition of the measures. The following section was measured there by Mr. Bowie, who has kindly given me the use of his record:

1.	Black shale	3′
2.	*Coal bed* K ?	3′

3. Shale	0′	6″
4. Gray sandstone	10′	6″
5. Black shale	1′	
6. *Coal*, divided midway by shale, 1″, J	2′	5″
7. Shale and gray sandstone	18′	3″
8. *Coal bed* I	0′	8″
9. Shale	1′	
10. Gray sandstone	18′	6″
11. Yellow sandstone	60′	
12. Shale	1′	
13. *Coal bed* H	0′	6″
14. Shale	1′	6″
15. Gray sandstone	15′	
16. *Coal bed* G	1′	6″
17. Shale	1′	
18. Gray sandstone	7′	
19. Black shale	14′	
20. *Coal bed* F	3′	4″
21. Shale	7′	9″
22. Sandstone	4′	6″
23 Shale	8′	6″
24. *Coal bed* E	1′	6″
25. Shale	38′	3″
26. *Coal bed* D	3′	
27. Interval	61′	
28. *Coal bed* B	4′	
29. Argillaceous shale	30′	
30. *Coal bed* A	0′	10″
31. Shale	0′	10″
32. Argillaceous sandstone	14′	6″
33. Yellow sandstone	150′	

The lettering of the coal beds is in accordance with the generalized section. *Coal bed* C is not given in this section; it is exposed at the point of the bluff between Bailey and Shaw gulches at 33 feet above *Coal bed* B. An imperfect exposure made with the hammer showed 2 feet of coal, but neither the top nor the bottom of the bed was reached.

Coal bed G varies from 3 inches to 18 inches. *Coal bed* F is well shown in the bed of the gulch, where the structure is clearly the same as in Shaw gulch. *Coal bed* E is imperfectly exposed in the stream bed; but *Coal bed* D is well shown in the side of the gulch where it has been prospected. *Coal bed* B has been opened at the end of the bluff where the thickness is as given. *Coal bed* A is utterly insignificant here, being but 10 inches in Mr. Bowie's section and 14 inches where seen in the gulch by the writer.

The great sandstone at the base of the section is reached just east from the mouth of the gulch. It has the same characteristics everywhere along the east face of the field. The thickness as given by Mr. Bowie is per-

haps the extreme, for the mass is not invariably a compact sandstone, but often shows great beds of sandy shale, sometimes even clay shale, the whole merging into the clay beds or beds of passage to the Fort Pierre shales.

Newland Creek. This is the next stream southward and makes a cañon across the whole of the field. But no detailed examinations were made there. A distinct though gradual rise of the whole basin southward carries out the highest members of the series before Newland creek is reached, so that almost midway in the basin, the great sandstone with *Halymenites* is at the top of the mesa. The measures above that sandstone are probably not more than 150 feet thick and no exposures were found to yield a section. Mr. Bowie's observations along the eastern face of the field at and beyond Newland creek show that the *coal beds* become thicker than they are further north, as indeed is suggested by the section in Bailey's gulch. A thick bed is worked on a tributary to Newland creek, which Mr. Bowie thinks is equivalent to the Shaw coal. The section of the bed as given by him is:

Coal	1′ 8″
Clay	0′ 7″
Coal	2′
Shale	1′ 2″
Coal	1′

Relations of this Field.

Careful search was made everywhere for fossil remains, but nothing was found aside from the fucoid, *Halymenites major*, and some palm leaves. *Halymenites* occurs abundantly in the sandstone overlying *Coal bed* H, and a few specimens were observed in the sandstone at the base of the series, which was examined at but two localities. The palm leaves were obtained in the Rockvale shaft, at fully one hundred feet below *Coal bed* H. The thickness of measures included between the upper and lower limits of the fucoid is more than four hundred feet.

This distribution of the fucoid is of no little interest. The writer* has shown that along the South Platte river, north from Denver, *Halymenites* occurs throughout a great mass of sandstone, where it is associated with forms proving the rock to belong to the Fox Hills group of the Upper Cretaceous. Dicotyledonous leaves occur there in the same sandstone.

In the Trinidad coal-field of southern Colorado and northern New Mexico, the writer† recognized a persistent sandstone, 60 to 80 feet thick, as marking the base of Laramie group. This sandstone, which occasionally holds a coal bed, contains *Halymenites major* in profusion, while that fossil occurs neither above nor below this horizon. At one locality, the the sandstone contains a *Cardium*-like mollusk, but the specimens obtained are too indifferent for specific determination.

* Am. Journ. of Science, 3rd Series, Vol. xvii, p. 370.
† Amer. Journ. of Scie[illegible], 3rd Series, Vol. xviii, p. 132.

Along Galisteo creek, in central New Mexico, as well as on the Rio Grande, 100 miles further south, the writer has sought in vain for specimens of the *Halymenites*, both in 1879 and 1881. The fucoid seems to be wholly wanting in the Laramie area of central New Mexico.

Comparing the distribution at the several localities mentioned, we have as the vertical extent of the fucoid :

In northern Colorado, along South Platte............	700′+
In central Colorado, Cañon City field...............	400′
In southern Colo. and northern N. M., Trinidad field.	80′
In central New Mexico, Galisteo creek and Rio Grande.	0′

Halymenites major, along the eastern foot of the Rocky mountains, is as thoroughly diagnostic of the Fox Hills group a *Arthrophycus harlani* is of the Medina sandstone in the Appalachian region. The *Halymenites* sandstone of the Trinidad field, the lower 400 feet of the Cañon City column, and the enormous mass of sandstone on the South Platte, below St. Vrain's creek, are equivalent and represent the Fox Hills group, as generally accepted. Coal occurs in them all, but most abundantly in the Cañon City area. It should not be forgotten, however, that the South Platte locality is at 70 miles from the mountains. When the section has been made from the mountains to that locality, not a little of the productive coal series will be found represented on the Platte by this sandstone group.

The Fox Hills group, as generally accepted, thins out southward and finally disappears before reaching central New Mexico.

Stated Meeting, October 21, 1881.

Present, 15 members.

President, FREDERICK FRALEY, in the Chair.

Mr. Aubrey H. Smith presented his photograph for the album.

Letters of envoy were received from the Second Geological Survey of Pennsylvania, the Johns Hopkins University, and the Geological Survey of the United States.

Donations to the Library were received from the Gazette Hongroise; J. M. Schary's heirs, Prag; Royal Institute, Venice; Revue Politique; Royal Academy, Brussels; Nature; Essex Institute; S. H. Scudder; Board of Education, Providence, R. I.; Wesleyan University; Silliman's Journal; New York Academy of Science; Franklin Institute; Medical Jour-

nal and News; E. D. Cope; H. Phillips, Jr.; Geological Survey of Pennsylvania; American Journal of Mathematics; U. S. Geological Surveys; Commissioners of Education; J. Hotchkiss; A. W. Williamson, and the Geological Survey of Canada.

The deposit of the late Prof. J. F. Frazer's portrait in the Hall of the Society, by his son Prof. Persifor Frazer, during his absence in Europe, was on motion ordered to be placed on the minutes.

Mr. Patterson accepted by letter his appointment. (See last meeting.)

The following letter was read:

"*To the Secretary of the American Philosophical Society.*

DEAR SIR:—In reply to your inquiry under date of the 10th instant, it may be briefly stated that Carlile Pollock Patterson was born at Shieldsboro, Bay St. Louis, Mississippi, August 24, 1816. He was appointed midshipman in the United States Navy in 1830, served in the Mediterranean Squadron, and in 1836 returned home, and graduated from Georgetown College, Kentucky, in 1838. Having served as passed midshipman on the Coast Survey until 1841, he was again on naval sea service until 1844, and subsequently as lieutenant United States Navy, had charge of a hydrographic party on the Coast Survey for four years. In 1850 he took command of a Pacific mail steamship, and continued in that and other private business until 1861. He then returned to the Coast Survey as Inspector of Hydrography, and so remained until he was appointed Superintendent of this work in February, 1874. His death took place at "Brentwood," his residence near Washington, on Monday, August 15th, 1881.

Yours respectfully,

J. E. HILGARD,

In charge of Coast and Geodetic Survey.

The death of Dr. B. H. Coates, the oldest surviving member of the Society, on the 18th instant, aged 83 years and 11 months, was reported.

On motion, Dr. Ruschenberger was appointed to prepare an obituary notice of the deceased.

Prof. Haupt exhibited fragments of terra cotta from the Northern Pacific Railroad crossing of the Little Missouri river, produced by the spontaneous combustion of the Lignite beds between the clay-beds of the bad lands, and extensively employed for ballasting the railroad. Also specimens of silici-

fied wood, one of which may possess archæological value, showing as it does two distinct cuts with an axe; but Prof. Cope expressed the opinion that the chips had been made in the already silicified wood, which is soft enough to cut. At present the locality is high rolling ground destitute of springs, and showing no marks of volcanic action. Most of the standing stumps have diameters varying from one to two feet, but one of them measures nine feet.

A beautiful reduced contour map [in MS,] of the Bald Eagle mountain and Birmingham hills in Blair and Huntingdon counties, Pennsylvania, was exhibited by Mr. Lesley. It represents a recent survey for geological purposes made by Messrs. E. B. and O. B. Harden, Topographical Assistants on the State Survey. The peculiar form of the mountain range made visible by this survey will probably afford the long desired explanation of the structural character of the great faulted anticlinal of Sinking valley.

"Notes on a possible Adite element in the early history of Egypt," were read, in part, by Mr. Lesley; the reading of the remainder was postponed to another meeting.

Pending nominations Nos. 934 to 945 were read, and with the exception of nomination, No. 935 (on motion postponed) were balloted for.

A special report of the Finance Committee on the subject referred to it at the last meeting was read and adopted.

Respecting certain uninvested funds, the Committee on Finance received power to act.

Mr. Fraley reported that he had received and paid over to the Treasurer the quarterly rent from the Michaux Legacy, due October 1st, amounting to $131.18.

The following new members were declared duly elected:

Henry H. Gorringe, Lieutenant-Commander U. S. N.

Jedediah Hotchkiss, Esq., Stanton, Va.

Charles C. Jones, Jr., Esq., Augusta, Georgia.

John Evans, Esq., F.R.S. Nash Mills, Hemel-Hempstead, England, President of the Anthropological Society.

Philip Price Sharpless, Esq., West Chester, Pennsylvania.

Charles A. McCall, M.D., 3941 Chestnut Street, Philadelphia.

C. L. Doolittle, Professor of Mathematics and Astronomy, Lehigh University, Bethlehem, Pennsylvania.

Mansfield Merriman, Professor of Civil Engineering, Lehigh University, Pennsylvania.

Rev. A. Renard, Soc. Jes., Director of the Musée Royal, Brussels.

J. B. Stallo, Esq., Cincinnati, Ohio.

Wm. E. Gladstone, Prime Minister of England.

And the meeting was adjourned.

The Brain of the Cat, Felis domestica. 1. Preliminary Account of the Gross Anatomy. With four plates. By Burt G. Wilder, M.D., Professor of Comparative Anatomy, etc., in Cornell University, and of Physiology in the Medical School of Maine, Member of the Am. Neurological Association, etc.

(Read before the American Philosophical Society, July 15, 1881.)

This paper is in four parts:—A. Introduction. B. The macroscopic vocabulary of the brain. C. List of points to be elucidated. D. Explanation of the plates.

A. INTRODUCTION.

The present paper is the first of a series of contributions to the knowledge of the brain of the domestic cat. A second—*A Description of the Cerebral Fissures, together with their Synonymy*—has been nearly ready for a year, and a brief preliminary abstract of it has been published (Wilder *8*),* but it will more properly follow the present general account of the entire brain.

The title of the series is made comprehensive in order that the subject may be discussed from any point of view. I hope, therefore, that others

*This number refers to the list at the end of this paper. In that list, the names of the *authors* are placed in *alphabetical order*. The titles of *separate works* are designated by *letters*, and their order has no significance. The titles of *papers* are *numbered*. In the case of papers published between 1800 and 1873, the numbers correspond to those in the chronological "Catalogue of Scientific Papers," published by the Royal Society of London. In other cases the numbers are only provisional, and are printed in italics.

The references are made as follows: the name of the author is given first, unless the author has been indicated already; then follows the letter or the number by which the title of the work or paper is designated upon the list; if a Roman numeral is given it denotes the number of the volume; and the last number is that of the page. The system of references to a List was followed by me in 1872, in the paper entitled Intermembral Homologies (10), and has been since adopted by others.

may be led to treat certain topics according to the special opportunities which they may enjoy, and that thus, eventually, there may be available for workers in Human, Veterinary and Comparative Anatomy, a complete account of the Gross Anatomy, the Histology, the Development, the Functions, and the Taxonomic Relations of the brain of a common mammal.

That the domestic cat is not only common in most civilized lands, but otherwise well adapted to serve as the basis for work upon other forms, including man, has been urged by Straus-Durckheim (A. pp. xiv and 54), H. S. Williams (A, iii), Mivart (B, ix), and the writer (*2*).

Subsequent experience has abundantly confirmed the views expressed in the paper last named, and has even removed my previous somewhat unfavorable impression respecting the availability of the cat for physiological experimentation.*

That the idea of employing the cat as an introduction to the study of other forms is neither original nor of recent adoption, may be seen from the work of Straus-Durckheim, and from the following passages in my papers :—

> "Nearly twenty years ago†, the late Professor Jeffries Wyman, in commenting upon the unsatisfactory nature of some notes of dissections, said : 'Much of this is due to the lack of suitable standards for comparison. The human body is not a suitable standard for the lower vertebrates. The best thing any anatomist can do is to prepare complete accounts of the structure of a few forms, each typical of some large group. The fowl could represent the birds, and the cat the mammals. The cat's anatomy should be done first, because it would serve as an introduction to human anatomy, and thus become an important aid to medical education.'" Wilder, *2*, 5.

Eight years ago, in a paper (11) upon the outer cerebral fissures of certain mammals, I offered the following suggestion :—

> "But before any final work can be done in respect to fissures, we need a complete account of the brain of some one mammal, giving its appearance from all sides, sections and dissections of all parts, and demonstrations of the relations which may exist between the fissural pattern and the internal structure ; then a full series of figures representing all the stages of development, both of the brain as a whole, and of its parts. On some accounts the fox would be the most useful species, but as it is not to be had in large numbers, and as dogs are ineligible as a standard, from the breed differences as well as from the usual complexity of the fissural pattern, we shall probably find the cat most available for the purpose. Such a work would form a fitting continuation of Straus-Durckheim's magnificent monograph of the Osteology and Myology of that animal. It

*The fiercest cat, provided it can once be induced to enter a bag, is managed almost as easily as a rabbit. Ether and chloroform act quickly and surely, and I have never encountered any serious difficulties, whether in the laboratory or lecture-room, in performing the experiments commonly employed for physiological illustration. Of course, these experiments were all *callisections*, that is, done by the aid of anæsthetics. In my opinion, as elsewhere expressed (*10*), *sentisection* or painful vivisection is rarely necessary or justifiable.

† It was in 1860, now twenty-one years ago.

is one of the tasks which I wish to accomplish, but I trust this will not deter others from undertaking it."

Since the above was written, I have lost no opportunity of accumulating materials for the illustration of the encephalic anatomy of the cat, and the museum of Cornell University now contains more than 220 preparations of the brain of that animal. A few of these are the entire organ, or its undissected halves ; the larger number are dissections for the sake of showing certain points in its structure.

At the outset, I hoped to find that, excepting purely histological matters, the structure of the human brain was so fully known as to require little more than the identification and description of the corresponding features in the cat. It was soon apparent, however, that some points of considerable morphological importance were as yet undetermined, or at least presented very unsatisfactorily in the standard works. To the deficiencies or positive errors of the published accounts, was added the difficulty of obtaining examples of the human brain in such a condition as to serve for the determination of doubtful points. After considerable observation and enquiry upon the subject, I am constrained to affirm that, by the ordinary method of extraction, the freshest human brain is so distorted as to be useless excepting for the roughest kind of enquiry, while the average dissecting-room brain is often only fit to be examined with a spoon.

Theoretically, of course, the anatomy of the human brain is to be learned only by the examination of that organ. Practically, however, so great are the difficulties of obtaining, preserving, and dissecting it, that, with most persons, a certain expenditure of time and money upon cats' brains will be more productive than if devoted to the brains of human beings.*

After spending more than twenty years in the study and teaching of anatomy and physiology, aided by the best models and plates, I feel that nearly all my real and substantial knowledge of the brain has been derived from that of the cat. Nor has the time yet come when I can examine a cat's brain for an hour, without correcting some misapprehension, learning something new, or at least gaining some fresh conception respecting the organization or functions of the organ, or its possibilities in the way of variation.

The present paper concerns only the *gross anatomy* of the brain, and even that is treated in only a general way. I fully recognize the great, perhaps the paramount, importance of a complete account of the *histology* of the organ, if only as a basis for the physiological, pathological and

*I have expressed elsewhere (2) the belief that, of all the more easily accessible animals, the cat offers superior advantages for preliminary anatomical work, but of course a large amount of information may be gained from the dissection of any mammal, aside from the mere skill in the use of instruments which comes from their actual employment upon the organs. Hence the following quotation from Solly (A, 93) is given with entire approval:—

"I am sure that whoever will take the trouble to go over this dissection [of the rabbit's brain] once or twice before attempting that of the human brain, will find his path much facilitated by the knowledge and the manual dexterity he will have acquired."

psychological observations which are constantly making in all parts of the world. But, with all deference to the presumed views of the many and indefatigable workers in this finer field, I hold that the more urgent need is for a provisional, at least, *identification and nomenclature of the visible parts.*

I am loth to believe that the authors of some histological contributions are not altogether clear upon the position and relations of the parts concerned; but I apprehend that many readers of such contributions fail to appreciate their excellencies or to recognize their defects from the lack of an adequate familiarity with the gross anatomy of the brain; a lack which seems almost unavoidable so long as the chief dependence is placed upon the text-books, or upon the appearances presented by human brains in the condition in which they commonly find their way to the dissecting-table.

Had a recent writer employed the fresh or well-preserved brain of a cat in place of the (presumably) distorted and semi-decomposed human organ, he never could have published a paper "De la non-existence des trous de Monro;" nor, indeed, does the acceptance of a paper with such a reactionary title indicate that the editors of "Progrès Médicale, Nos. 25, 26," have left the beaten track in this respect.

Whoever will carefully examine the fresh or well-preserved brains of cats need not, unless he prefer to accept authority in place of the evidence of his eyes, either doubt the existence of the "Foramina of Monro," or believe that these openings are primarily for the "transmission of the choroid plexus." Neither need he believe that "the third ventricle communicates with the fifth" in any animal, or at any period of development; that "the great transverse fissure" is a real cleft from the outside of the brain into its "ventricular cavities;" that the "corpora quadrigemina, pineal body, corpora geniculata and thalami are internal parts of the cerebrum;" or that, in the cat at least, the thalami enter, in the slightest degree, into the formation of "the floor of the lateral ventricles."

With the view of aiding in the correction of some of such current misapprehensions, and paving the way for more sound and enduring work in other directions, the present paper is purely morphological, and all teleological considerations have been excluded.

Moreover, as has been said already, only a general view of the organ is here given. Each part of the brain requires more or less extended monographic treatment. Not only should its average or usual form, structure, and connections be determined, but its variations should be noted, and correlated with known differences in respect to the age, sex, breed, color and disposition. Anomalies also should be recorded. Of course, such striking cases as the absence of the callosum, reported by the writer in 1879 (*13*) would be at once remarked; but in many other respects we are as yet unaware what is the real normal condition, and are hence unable to determine the extent of departure therefrom. The small size of the cat's brain and the ease with which large numbers may be obtained and preserved, render it peculiarly adapted for this line of enquiry.

It is generally admitted that the brain might be of use in the determination of zoölogical affinities. That it is really so seldom employed for this purpose, excepting as furnishing merely corroboratory evidence, is largely due to the vagueness of our information, which prevents exact comparisons. Now the Carnivora in general, and the Felidæ in particular, form very compact and well-defined groups; hence the careful comparison of the parts of the cat's brain with the homologous parts in other members of the family and order should not only be comparatively easy, but also afford some clues to the functions of the parts, as well as furnish a basis for taxonomic considerations.

It would probably be difficult to estimate the influence, upon both physiology and systematic zoölogy, of the sum of knowledge which may be available when the brain has received an amount of time, labor and thought equal to that which has been devoted to the skull.

Considering the abundance of the domestic cat in most parts of the world where anatomy is cultivated, very little use seems to have been made of its brain. In several papers (Owen, 35), Krueg (*2*), Benedikt (*1* and *2*), Pansch (*1*), the cerebral fissures are more or less fully discussed; but I am not acquainted with any special paper on the entire organ, and the only figures of the structure known to me are the following: The mesal surface is shown by Leuret et Gratiolet (A, pl. v, fig. 3); the procœliæ (ventriculi laterales) are shown by Gegenbaur (A, 508, fig. 286); and the dorsal and ventral surfaces are partly seen in connection with the nerves in Bourgery and Jacob (A, pl. xvi).

The sheep's brain seems to have been selected by Foster and Langley (A), and by Morrell (A), partly, at least, on account of the ease with which the head may be procured, thus avoiding the killing of an animal for the sake of the brain. But cats are so plenty, and so readily killed by chloroform, that no objection need exist upon that score, and the brain is removed, preserved and dissected much more conveniently than that of the sheep.*

The small size of some of the parts of the cat's brain is an objection, no doubt; but this is atoned for by the number of preparations one may make and keep, and by the ease with which the entire organ may be held or placed in any position so as to obtain the best light without the danger—which is ever present with larger brains—of tearing by its own weight.

B. THE MACROSCOPIC VOCABULARY OF THE BRAIN.

In a recent paper (*9*), I have presented somewhat in detail both the grounds for attempting a Revision of Anatomical Nomenclature, and the results of that revision.

With a slight rearrangement, and some unimportant verbal alterations, the following paragraphs remain as there published (pp. 123, 137), and

*For a detailed account of the methods of preparing the cat's brain, see my paper in "Science" (*11*).

embody a brief statement of "the objects of the present revision, the considerations upon which it is based, and the methods which have been pursued :"

"To facilitate the acquisition and communication of accurate anatomical knowledge, by rendering the vocabulary equally applicable to all vertebrates, and equally intelligible to all nations.

"That the convenience and preferences of all existing anatomists should be held of little moment as compared with the advantages which reform may ensure to the vastly more numerous anatomical workers of the future.

"That the test of the accuracy and completeness of a description is, not that it may assist, but that it cannot mislead.

"That *brevity* is an especially desirable characteristic of such names as are most frequently employed.

"To include in this vocabulary, so far as practicable, only such terms as are brief, simple, significant, of classical origin and capable of inflection.

"To propose as few changes as possible, and to introduce new names only for parts apparently unknown or unnamed before (*e. g.*, *crista fornicis*), or in the place of semi-descriptive appellations undesirably long or incapable of inflection, as *e. g.*, *cimbia* for *tractus transversus pedunculi*, *porta* for *foramen Monroi*.

"When a part is known by a descriptive phrase, to select therefrom some characteristic word as the technical designation ; *e. g.*, *iter* (*a tertio ad ventriculum quartum*).

"When two or more parts are similar, or have similar relations, to distinguish them by joining to some common title already in use prefixes indicative of their relative positions ; *e. g.*, *postgeniculatum*, *prægeniculatum*.

"To shorten the names of several parts by omitting the word *corpus*, and using the neuter adjective as a substantive.

"To discard terms which indicate *size*, those which refer to the *natural attitude* of man or animals, most *vernacular* names, and all names of the reproductive organs which have been applied needlessly to other parts of the body.

"To keep modern usage, and the rules of classical etymology constantly in mind, but not to be hindered thereby from the employment or even the formation of terms which are eminently desirable from the practical standpoint."

At my request, the publisher of "Science" kindly sent copies of the two numbers containing the article to leading scientific, medical and literary journals, and to about 22 naturalists or physicians who make more or less use of anatomical terms in their writings. There has been scarcely time for any extended criticism of the proposed changes, but as the article contained a very distinct request for suggestions, I am disposed to infer that anatomists are at least willing to let the new terms have a fair trial in the present paper, the preparation of which was announced at the head of the article.

The following are the only published comments upon the subject, which have come to my notice :—*

In *The Nation* for April 12, 1881, is a brief notice of the article, evidently

* Since this was written, The Journal of Nervous and Mental Disease for July, 1881 (652–661), has reprinted from the paper (9) the List of names of encephalic parts, and regards the new nomenclature as supported by "rather satisfactory arguments." See also p. 562 of this paper.

by an anatomical teacher, from which I quote the following: "There is certainly ample room for it [the reform proposed], but one cannot help thinking that in his desire for set names, Professor Wilder approaches pedantry." In view of what might have been expected from so critical a journal, I am disposed to feel more encouraged by the admission than disheartened by the objection.

Dr. Oliver Wendell Holmes wrote me the following letter upon the subject, which, with his permission, was printed in "Science" for June 4, and is here, in part, reproduced :—

BOSTON, May 30, 1881.

DEAR DR. WILDER :—I have read carefully your paper on Nomenclature. I entirely approve of it as an attempt—an attempt which I hope will be partially successful, for no such sweeping change is, I think, ever adopted as a whole. But I am struck with the reasonableness of the system of changes you propose, and the fitness of many of the special terms you have suggested.

The last thing an old teacher wants is, as you know full well, a new set of names for a familiar set of objects. It is hard teaching old professors new tricks. So my approbation of your attempt is a *sic vos non vobis* case so far as I am concerned. * * *

What you have to do is to keep agitating the subject, to go on training your students to the new terms—some of which you or others will doubtless see reasons for changing—to improve as far as possible, fill up blanks, perhaps get up a small Manual in which the new terms shall be practically applied, and have faith that sooner or later the best part of your innovations will find their way into scientific use.

* * * The plan is an excellent one—it is a new garment which will fit Science well, if that capricious and fantastic and old-fashioned-dressing lady can only be induced to try it on.

Always very truly yours,

O. W. HOLMES.

Dr. Holmes's literary authority, as well as the fact, perhaps less generally known, that for 33 years he has been the Professor of Anatomy in the Medical School of Harvard University, will give great weight to his approbation of my undertaking.

In Science for April 29, 1881, Dr. E. C. Spitzka of New York, well-known as an indefatigable worker in encephalic anatomy and histology, published (7) a letter to the Editor respecting my article. Dr. Spitzka generously puts aside the natural feeling of disappointment that a task which he had contemplated for several years should be, however imperfectly, performed by another, and, together with valuable practicable suggestions upon several important points, comments as follows upon the general subject :—

"It is with mingled pleasure and profit that I have read the very suggestive paper on Cerebral Nomenclature contributed to your latest issues by Prof. Wilder. Some of the suggestions which he has made have been

latent in my own mind for years, but I have lacked the courage to bring them before my colleagues. Now that he has broken ground, those who prefer a rational nomenclature to one which like the *present* reigning one, is based upon erroneous principles, or rather on no principles at all, will be rejoiced at the precedent thus set for innovations. As Prof. Wilder has invited criticism, I take the opportunity of offering the following remarks upon the leading points of his papers, in so far as they refer to the brain alone.

"1. The principles announced are such as zoötomists and anatomists generally will agree with, to the fullest extent. * * * I have no hesitation in saying that the labor of the anatomical student will be diminished fully one-half when this nomenclature shall have been definitely adopted. * * * In Germany the older system has gone out of use almost entirely, and not the least charm about the works of Henle, Schwalbe, Forel and Gudden, is the fact that these authors have more or less done away with the ambiguous terms once rampant.

"3. In proceeding to comment on some of the terms proposed by Prof. Wilder, I wish it to be distinctly understood that I do so merely tentatively and to promote discussion; in so doing I feel certain that I am carrying out that writer's wish. It is but just to state that the majority of the terms cannot be discussed—they are perfection and simplicity combined."

I think Dr. Spitzka does himself scant justice in ascribing his non-presentation of the subject to "a lack of courage." But I can well understand that the demands of an active practice have forced him to defer from time to time the somewhat onerous task of putting his material into shape for publication.*

In the following discussion of the macroscopic vocabulary of the brain, I have transcribed freely from the article above named, introducing such modifications as have since appeared to me desirable.

The terms employed by anatomists form two divisions: those which indicate the *position* or *direction* of organs, and those by which the organs themselves are designated. Since, also, writers have usually treated of them separately, it will be convenient here to consider anatomical *toponomy* and *organonomy* under distinct headings.

Terms of Position and Direction—Toponomy.

Dr. Barclay's volume had especial reference to this division of the subject, and its key-note is struck in the following paragraph (A, 5):

"The vague ambiguity of such terms as superior, inferior, anterior, posterior, &c., must have been felt and acknowledged by every person the least versant with anatomical description."

Dunglison admits (A, 61) that "Great confusion has prevailed with anatomists in the use of the terms before, behind, &c." Dr. Spitzka has forcibly stated (*1*, 75, note 1) the objections to the use of anterior, &c., and their unsuitability is tacitly conceded in the employment of other terms by

*Since this paper was presented, Dr. Spitzka has published an able contribution (*10*) to our knowledge of the metencephalon, in which the toponomical terms herein suggested are employed.

several writers who do not explicitly condemn the current toponomy: Gegenbaur (A, 491), Mivart (A, 69), Cleland (*1*, 170), Rolleston (B, 33, note), &c.

Finally, the need of a radical change of base has been proclaimed in one of the very strongholds of anthropotomy:—

"Now that the more extended study of comparative anatomy and embryonic development is largely applied to the elucidation of the human structure, it is very desirable that descriptive terms should be sought which may, without ambiguity, indicate position and relation in the organism at once in man and animals. Such terms as cephalic and caudal, dorsal and ventral, &c., are of this kind, and ought, whenever this may be done consistently with sufficient clearness of description, to take the place of those which are only applicable to the peculiar attitude of the human body."—Quain, A, I, 6.

This is certainly explicit as to the principle involved, and it is to be hoped that later editions of this standard Human Anatomy may display its practical application to the body of the work.

How slender is the justification for retaining a toponomical vocabulary based upon the relations of organisms to the surface of the earth, appears more fully when we reflect that the assumed standard, for the higher vertebrates at least, is man in his natural erect attitude; yet that both man and animals are more often examined and compared with the *back downward*, this being an attitude truly characteristic of only that infrequent "subject," the sloth.

As a single illustration of the logical inconsistencies into which we are led by the use of the current toponomy, take the series of possible designations of the direction of some vertebral spinous process which projects toward the skin of the back at, or approximately at, a right angle with the myelon. With man the direction in which it points is *posterior*, but with a cat it is *superior*, while with an ape or a bird it is somewhere between the two; with all four, when on the dissecting table, it would be usually *inferior*. Finally, with a flounder the corresponding direction would be *horizontal* or *sidewise*.

In short, to designate the locations of organs by the relations of animals to the surface of the earth, which relation differs in nearly allied forms, and varies with the same individual according to circumstances, is as far from philosophical as it would be to define the place of a house or a tree by reference to the planet Jupiter, or to assume that mankind naturally face the rising sun, and hence to designate our right and left as the south and north sides of the body.

The present tendency of accurate anatomical description is to refer the position or direction of all parts and organs to an imaginary plane dividing the body into approximately equal right and left halves; hence it is desirable to designate this middle plane, or any line contained therein, by a word which is at once significant, short, and capable of inflection. Dr. Barclay proposed *mesion*, and *mesial* has been generally used; but would

it not better to adopt the very term employed by the Greeks to signify the middle, *meson*, τό μέσον, equivalent to the more ponderous Latin *meditullium?* The corresponding adjective is *mesal*, and the adverb *mesad*, while in combination it becomes *meso*.

The following general terms were also proposed by Barclay, and have been more or less systematically employed by Owen, Huxley and others : *Dorsal, ventral, dextral, sinistral, lateral*, with the corresponding adverbial forms *dorsad*,* etc. Should the alleged correspondence of the ventral region of the Vertebrate with the tergal region of the Arthropod prove to be one of true homology, it may be desirable in time to discard *dorsal* and *ventral* for more suitable terms, but for the present, if on practical grounds alone, it seems well to retain them.

Barclay proposed *atlantal* and *sacral* for the designation of the position of parts lying toward the head or the tail, in reference to an imaginary plane dividing the trunk at the middle of its length. But these terms were not applicable to parts beyond the atlas and the sacrum, so that new words were applied to the regions of the head. Perhaps this needless complication has hindered the general adoption of Barclay's nomenclature nothwithstanding its many admirable features. At any rate, *cephalic* and *caudal* are much more acceptable terms, and are practically unobjectionable, although certain theoretical difficulties readily suggest themselves.

Proximal and *distal, central* and *peripheral* are in common use, and the general employment of their inflections and derivatives is only a question of time. *Proximal* and *distal* seem to be more applicable to the limbs and their segments, while *central* and *peripheral* may be employed for vessels and nerves.

Ental, and *ectal* were proposed (9) as substitutes for the more or less ambiguous words *inner* and *outer, interior* and *exterior, deep* and *superficial, profound* and *sublime*. Derived respectively from ἐντός and ἐκτός their significance is obvious, while their brevity and capacity for inflection will probably commend them to accurate working anatomists.

The Names of the Parts—Organonomy.

ABBREVIATIONS OF THE MORE GENERAL NAMES OF ENCEPHALIC PARTS.

Ar.—Area.	F.—Fissura.	Px.—Plexus.
C.—Cœlia.	Fm.—Foramen.	R.—Recessus.
Clm.—Columna.	Fn.—Funiculus (rootlet).	Rx.—Radix.
Cn.—Canalis.		Sl.—Sulcus.
Cp.—Corpus.	Fs.—Fossa.	Spt.—Septum.
Cr.—Crus.	Inc.—Incisura.	T.—Tuber.
Crs.—Crista.	L.—Lobus.	Tr.—Tractus.
Cs.—Commissura.	Ll.—Lobulus.	Tl.—Tela.
Em.—Eminentia.	Pt.—Portio.	

*In his recent paper (8) on the Evolution of Mammals, as printed in "Nature," Jan. 6, 1881, p. 228, Huxley uses the term *dorsad*.

ABRIDGED SYNONYMY OF THE CEREBRAL FISSURES.

ABBREV.	*Flower*, 1869, 28. *Leuret*, 1839, A. *Huxley*, 1861, 70; 1872, A.	*Owen*, 1868, A.	*Wilder*, 1873, 10.	*Krueg*, 1880, 2.	*Adopted in the present paper.*	
a.		Ant. branch of ectosylvian	Ant. upright of ectosylvian	Anterior.	Anterior.	a.
an.				Ansata.	Ansata.	an.
cf.		Part of medilateral.	Part of medilateral.	Confinis	Confinis.	cf.
cl.		Callosal.			Callosalis.	cl.
cor.		Coronal.	Coronal	Coronalis.	Coronalis.	cor.
cr.	Crucial	Frontal.	Frontal	Cruciata	Cruciata.	cr.
dg.				Diagonalis.	Diagonalis	dg.
fm.					Fimbriæ.	fm.
fl.		Part of falcial.		Genualis	Falcialis	fl.
hmp.	Hippocampal. Dentate. *Huxley*, 1861.	Hippocampal.		Hippocampi.	Hypocampæ	hmp.
in					Intermedia	in.
l.		Lateral	Lateral.	Lateralis.	Lateralis	l.
ln					Lunata	ln.
ml.		Part of medilateral	Part of medilateral.	Medilateralis	Medilateralis.	ml.
mr.		Marginal.		Suprasplenialis	Marginalis	mr.
ol.			Ectorhinal.	Olfactoria.	Olfactoria.	ol.
p.		Post. branch of ectosylvian	Post. upright of ectosylvian.	Postica.	Postica.	p.
pcr.				Postcruciata.	Postcruciata	pcr.
pmr				Postsplenialis	Postmarginalis.	pmr.
prd					Postradicalis.	prd.
prh.		Part of ectorhinal	Part of rhinal.	Rhinalis posterior.	Postrhinalis	prh.
prrd					Præradicalis.	prrd.
ps		Postsylvian.	Part of supersylvian	Suprasylvian posterior	Postsylviana.	ps.
rh		Part of ectorhinal	Part of rhinal	Rhinalis.	Rhinalis	rh.
s.	Sylvian	Sylvian.	Sylvian.	Sylvii.	Sylviana	s.
sfl		Part of falcial		Rostralis.	Subfalcialis.	sfl.
sp	Callosomarginalis (Flow. and Huxley).	Supercallosal.		Splenialis	Splenialis.	sp.
so	Supraorbital (Flow.).		Presylvian.	Præsylvii.	Superorbitalis	so.
ss.		Supersylvian.	Postsylvian & supersylvian.	Suprasylvii	Supersylviana.	ss.

ABBREVIATIONS OF THE CRANIAL NERVES. (See fig. 3.)

For convenient comparison, the numerals applied by Sœmmering are prefixed to the proper abbreviations.

vi. *abd.*—Abducens.
xi. *ac.*—Accessorius (spinalis).
viii. *au.*—Auditorius. (Portio mollis.)
vii. *f.*—Facialis. (Portio dura.)
ix. *gph.*—Glossopharyngeus.
xii. *hg.*—Hypoglossus.
iii. *ocm.*—Oculomotorius. Motor communis.
i. *ol.*—Olfactorius.
ii. *op.*—Opticus.
iv. *tr.*—Trochlearis. "Patheticus."
v. *trg.*—Trigeminus. Trifacialis.
x. *v.*—Vagus. Pneumogastricus. Par vagum.

LIST OF THE PARTS OF THE CAT'S BRAIN WHICH ARE VISIBLE TO THE UNAIDED EYE.

To avoid repetition, this list is accompanied by the abbreviations which are used upon the plates, and, for convenience of reference, the names are arranged in the alphabetical order of the abbreviations. Only the abbreviations of *general* names are capitalized. The numbers following the names indicate the figures upon which the parts are shown, or, in a few cases, the pages on which they are mentioned.

Most of the names are those in common use, with the omission of superfluous elements like *corpus*, and the genitives of the names of more comprehensive parts. Most of the apparently new names will be found to be old acquaintances under such thin disguises as *translation*, *transposition*, *abridgment*, and the *substitution of prefixes* for qualifying words. In a few cases the old names, are wholly discarded for briefer new ones. Most of the new names, however, refer to parts apparently unobserved hitherto (*e. g.*, *crista*, *carina*, *delta*), or to parts which—although probably observed—seem not to have been regarded as needing a special designation (*e. g.*, *aula*, *quadrans*, *pero*).

So much of each name as immediately follows the abbreviation, is regarded as a sufficient designation of the part under ordinary circumstances; sometimes it may be desirable to add the words in parenthesis.

a.—Aula. The cavity of the primitive prosencephalon, or Lobus communis. 3, 13, 16. See p. 540.

abn.—Albicans (Corpus). 3, 4, 11.

alb.—Alba (Substantia). White matter. 13, 14, 20.

apx.—Auliplexus. Not distinctly shown. See p. 542.

arb. vt.—Arbor vitæ (cerebelli). 4.

Ar. cr.—Area cruralis. 3, 11.

Ar. icr.—Area intercruralis. 3, 11.

Ar. el.—Area elliptica. 3.

Ar. ov.—Area ovalis. 3.
Ar. ppn.—Area postpontilis. 3.
Ar. prch.—Area præchiasmatica. 3.
Ar. spt.—Area septalis. 4, 16.

ca.—Carina (fornicis). Not shown, see p. 556.
cb. or *hem.*—Cerebrum; prosencephalon; hemisphæræ. 1, 2, etc.
cbl.—Cerebellum. 1, 2, 12, 15.
cd. s.—Cauda striati. See p. 542.
cel. m.—Cella media (procœliæ). 15.
ch.—Chiasma (NN. opticorum). 3, 4, 5, 11, 16.
cin.—Cinerea (Substantia). Gray matter. 14, 20.
cl.—Callosum (Corpus). 4, 13, 15, 16, 17, 20.
clc.—Calcar. Hippocampus minor. Not in the cat.
clv.—Clava. 12.
Clm. d.—Columna dorsalis myelonis. Posterior white column of the spinal cord. 1.
Clm. f.—Columna fornicis. 4, 10, 13, 14, 16.
Clm. l.—Clm. lateralis myelonis. 1, 3.
Clm. v.—Clm. ventralis myelonis. 3.
cmb.—Cimbia. Tractus transversus pedunculi. 3, 8, 9, 11.
cn.—Conarium. Corpus pineale. 7, 10. See p. 562.
Cn. ce.—Canalis centralis (myelonis). 4.
Cr. cb.—Crus cerebri. 2, 4, 9, 11, 18, 19.
Cr. ol.—Crus olfactorium. 4, 5.
Crs. f.—Crista (fornicis). 4, 14, 16, 20. (See Wilder, 7.)
Cs. f.—Commissura fornicis. 14.
Cs. h.—Commissura habenarum. 4, 6.

d.—Dura (mater). Not shown.
dc.—Diacœlia. Ventriculus tertius. 4, 6, 7, 16. See p. 539.
den.—Diencephalon, interbrain. 7, 9, 10.
dlt.—Delta (fornicis). 10, 14.
dpx.—Diaplexus. Plexus choroideus ventriculi tertii.—4, 16.
dtl.—Diatela. Roof of diacœlia.

Em. au.—Eminentia auditoria. 2, 3.
end.—Endyma ependyma. The lining membrane of the cœliæ.
epc.—Epicœlia. Ventriculus cerebelli. 4.
epen.—Epencephalon. Hind brain. 4.

f.—Fornix. 14, 15, 16, 17, 19, 20.
F.—Fissura. See list of cerebral fissures, p. 534.
F. dl.—Fissura dorsilateralis (myelonis). Postero-lateral fissure of the spinal cord. 1.
F. dms.—Fissura dorsimesalis (myelonis). 1.
F. vl.—F. ventrilateralis (myelonis). 3.
F. vms.—F. ventrimesalis (myelonis). 3.
Fm. cc.—Foramen cæcum. 3.

Fm. cn.—Foramen conarii. 6.
Fm. inf.—Foramen infundibuli. 6.
fmb.—Fimbria. Corpus fimbriatum. 14, 17.
fscl.—Fasciola. Fascia dentata and fasciola. 14, 17.

g.—Genu (callosi). 4, 17.

h.—Habena. Habenula ; pedunculus pinealis. 4, 7, 16.
hem.—Hæmisphæra. Hemicerebrum. 1, 2, 3, 4, etc.
hmp.—Hypocampa. Hippocampus major. 14, 15, 18, 19.
hph.—Hypophysis. Corpus pituitarium. 3, 4. See p. 562.

Inc. hmp.—Incisura hypocampæ. 11.
inf.—Infundibulum. 3.
ins.—Insula. Island of Reil. Not distinct in the cat. See p. 543.
it.—Iter (a tertio ad quartum ventriculum). Mesocœlia, *msc.* 4, 8.

L. l.—Lobus lateralis (cerebelli). 1, 2, 15.
L. ol.—Lobus olfactorius. 1, 2, 15, 17, 18.
L. tmp.—Lobus temporalis (hemisphæræ). 2.
Ll. ap.—Lobulus appendicularis (cerebelli). 2, 3.
Ll. hmp.—Lobulus hypocampæ. Ll. mastoideus. 2, 14, 17.
lm. alb.—Limes alba (radicis lateralis cruris olfactorii). 2, 5.
lm. cin.—Limes cinerea. 2, 5.
lq. c.—Liquor cœliarum. Liquor ventriculi.
ly.—Lyra (fornicis). Psalterium. 14. See p. 543.

mcs.—Medicommissura. Commissura mollis. 4, 16.
mcu.—Medicornu (procœliæ). Cornu temporale. Cornu descendens. 11, 14, 18, 19.
mpd.—Medipedunculus (cerebelli). Crus ad pontem. 8.
msc.—Mesocœlia. Iter. Ventriculus loborum opticorum mesalis. 4, 8.
msen.—Mesencephalon. Midbrain. Lobi optici, etc. 7, 9.
mtc.—Metacœlia. Ventriculus quartus, less the epicœlia. 4.
mten.—Metencephalon. Medulla oblongata. After-brain. 1, 2, 4, 12.
mtpx.—Metaplexus. Plexus choroideus medullæ. 3, 12.
mttl.—Metatela. Roof of metacœlia. 4, 12.
my.—Myelon. Spinal cord. 1, 2.

ob.—Obex. Not identified in the cat.
olv.—Oliva. Corpus olivarium. Not identified in the cat.
op.—Opticus (Lobus). Cephalic optic lobe; natis cerebri. 4, 7, 9, 18, 19.

p.—Porta (Monroi). Foramen Monroi. 14, 16, 18, 19. See p. 540.
pi.—Pia (mater). Not shown. See p. 543.
pcs.—Postcommissura. Commissura posterior. 4.
pgn.—Postgeniculatum, (Corpus). Corpus geniculatum internum. 7, 8, 9, 10.
po. ol.—Pero olfactorius. 16.
pop.—Postopticus (Lobus). Caudal optic lobe ; testis cerebri. 4, 7, 8, 9, 18, 19.

pn.—Pons (Varolii). 2, 3, 4, 9, 11.
ppf.—Postperforatus (Locus). 3, 4, 11.
ppx.—portiplexus. 18.
prc.—Procœlia. Cœlia prosencephali; ventriculus lateralis. 15, 16, 18, 19.
prcs.—Præcommisura. Commissura anterior. 4, 14, 16.
prcu.—Præcornu (procœliæ). Cornu anterius. 13, 15, 16, 18, 19.
pren.—Prosencephalon. Cerebrum. Hemisphæræ.
prgn.—Prægeniculatum. Corpus geniculatum externum. 7, 8, 9.
prpf.—Præperforatus, (Locus). Locus perforatus anterior. 3, 4, 11.
prpx.—Proplexus. Plexus procœliæ. 15, 18.
ps. ol.—Pes olfactorius. 16.
Pt. d.—Portio depressa (præperforati). 3, 11.
Pt. dien.—Portio diencephalica (cruris cerebri). 11.
Pt. msen.—Portio mesencephalica (cruris cerebri). 11.
Pt. p.—Portio prominens (præperforati). 3, 4, 11.
py.—Pyramis (metencephali). Pyramis anterior. 3, 4.
psc.—Pseudocœlia. Ventriculus septi lucidi; fifth ventricle. Not in the cat. See p. 549.
q.—Quadrans (cruris.) 11.

r.—Rima. Fissure of Bichat. 14, 17.
R. a.—Recessus aulæ. 14.
R. op.—Recessus opticus. 4, 11, 16.
R. prpn.—Recessus prepontilis. 4.
Rg. a.—Regio aulica. The complex region about the aula.
rhc.—Rhinocœlia. Ventriculus olfactorius. 16.

Tr. op.—Tractus opticus. 3, 11, 14, 19.
Tr. prh.—Tractus postrhinalis. 8.
tz.—Trapezium. 2, 3.

vl.—Velum (interpositum). Not shown. See p. 544.
vm.—Vermis (cerebelli). 1, 2, 15.
vv.—Valvula (cerebelli). 4.

A few of the terms included in the foregoing list need more extended mention.

The encephalic segments.—It is often convenient, and always more philosophical, to regard the brain as composed of a series of *segments* or *divisions*, each consisting of a cavity, with its sides, floor, and roof variously thickened, convoluted, or otherwise modified. So far as is known, the anatomical divisions most conveniently made correspond essentially with the series of embryonic vesicles.

To these divisions, the German anatomists, following, I believe, Von Baer, apply the names *vorderhirn*, *zwischenhirn*, *mittelhirn*, *hinterhirn*, and *nachhirn*, which are commonly rendered in English by *forebrain*, *'tweenbrain*, *midbrain*, *hindbrain*, and *afterbrain*.

In converting these vernacular terms into technical, anatomists have generally recognized the practical advantage of regarding the *Lobi olfactorii* as a segment apart from the cerebral hemispheres, under the name of *rhinencephalon*. The hemispheres, including the *striati*, etc., constitute the *prosencephalon*, and the *Lobi optici*, with the corresponding portion of the *Crura cerebri*, form the *mesencephalon*. So far, all agree. But the region including the thalami, between the prosen. and the mesen. has been variously called *deutencephalon*, *thalamencephalon*, and *diencephalon*. Unable to ascertain which has priority, I select the last as the shortest and most applicable.

Upon the names of the remaining parts of the brain there is more serious divergence of usage among writers. Owen (A, I, 293) calls it all *epencephalon*; but Huxley applies (A, 60) that name to the pons and cerebellum as a division separate from the medulla, which he calls *myelencephalon*, notwithstanding this term had been previously proposed by Owen (A, I, 268) for the entire "cerebro-spinal axis." In this, Huxley is followed by the English editor of "Gegenbaur" (A, xiii) notwithstanding his admission that a different nomenclature had been previously published in Quain (A, II, 755). The editors of "Quain" recognize the two divisions, and apply *epencephalon* to the pons and cerebellum, giving to the medulla proper the name *metencephalon*. On all accounts, this seems to me the best arrangement of terms for the encephalic segments, and is followed in the present paper.

The cœliæ, or encephalic "ventricles."—The incongruity of the anthropotomical designations of the encephalic cavities has been pointed out by Owen (A, I, 294, note), and the writer (9, 125).

The *canalis centralis* expands into a cavity which, although the first of

the series, is called the *fourth* ventricle. The more or less distinct cavities corresponding to the cerebellum and the Lobi optici are not called ventricles at all, and the *third* is between the thalami. The two "lateral" ventricles are rarely mentioned as the *first* and *second*, but since the numbers must be understood in order to account for the *third* and *fourth*, the student desires, in vain, to know which is the first and which the second. In point of fact, if the enumeration is begun at the cephalic end of the series, the lateral ventricles are the third and fourth, since there are well-developed ventricles in the *Lobi olfactorii*. Finally, a "*fifth* ventricle" is mentioned, which is not only at the greatest distance from the fourth, but has no normal connection with the other ventricles, and is, in fact, no part of the series.

In view of all this, the task of describing to students the highways and by-ways of the brain—which should be most attractive because therein is most clearly manifested the ideal arrangement of the organ—is one from which I shrink as from any other kind of solemn nonsense. To my mind, indeed, rather than go on as we have been going, it would be at once more philosophical and more intelligible to adopt the simple vocal device employed by Straus-Durckheim for the designation of the Ossa metatarsalia—"padion, pedion, pidion, podion, pudion"—and to re-christen the ventricles by, for instance, the names *pran, pren, prin, pron,* and *prun.*

Fortunately, however, another alternative is presented. Assuming that the terms *rhinencephalon, prosencephalon, diencephalon, mesencephalon, epencephalon* and *metencephalon* are to be retained, and that they are to be learned by successive generations of students, why should we not transfer the distinctive prefixes to the Greek word for ventricle, *κοιλία, cœlia?* This would give us *rhinocœlia, procœlia, diacœlia, mesocœlia, epicœlia,* and *metacœlia.*

These terms are capable of inflection, and the longest of them is no longer than the Latin *ventriculus,* which requires a prefix or qualifying word. These prefixes may be also employed for the designation of the membraneous roofs of the "third" and "fouth" ventricles, and the plexuses of these and the lateral ventricles. Thus we should have *metatela* and *metaplexus, diatela* and *diaplexus, proplexus, portiplexus,* and *auliplexus.* Two or more "ventricles" would be spoken of as *cœliæ,* while the "fifth ventricle," which is really no part of the series, may well be called *pseudocœlia.*

Aula.—I hope, before long, to justify more fully the proposition already made (Wilder, *5* and *9*), to consider the cephalic portion of the "third ventricle" between the *portæ* (Foramina Monroi), as a morphologically independent cavity under the name of *aula.*

Porta.—This is proposed as a convenient substitute for the phrase "Foramen Monroi." If the two orifices leading, respectively, from the two procœliæ ("lateral ventricles"), into the aula, and so communicating with the entire mesal series of cœliæ, were seldom employed, or even as frequently as "Foramen Magendie," there might be less call for a change of name; but, according to my view of the best method of studying the

brain, these slight orifices, which are but rarely demonstrated, and have never been, so far as I know, accurately figured, have a real and great morphical value, and should be frequently named ; hence the desirability of a short term capable of inflection. Since there is no other encephalic *porta*, the single word is sufficient ; but *Monroi* may be regarded as belonging thereto, in memory of the description of the parts by A. Monro *secundus* (A). See my paper (*3*).

Medicornu, etc.—In place of the terms *Cornu descendens*, etc., I have suggested that the three prolongations of the procœlia into the *Lobi temporalis, frontalis*, and *occipitalis* respectively, should be called *medicornu, præcornu*, and *postcornu*. The latter does not exist in the cat.

Rima.—This brief name is proposed as a substitute for the phrase "*rima transversa cerebri magna*," and its various classical or vernacular equivalents. That, in the cat, the connection of the two borders of the rima is complete, and capable of resisting a considerable pressure of air, alcohol or plaster, has been repeatedly demonstrated by me since the 25th of November, 1876. But the proper nervous tissue is interrupted from the dorsal border of the porta to near the tip of the medicornu, and, in so heavy a brain as that of man, the membraneous connections are readily torn during the extraction or manipulation of the organ ; see my paper, *9*, 186.

Proterma.—prtr.—The primitive *lamina terminalis* or *l. cinerea*. *Terma embryonis*. My reason for suggesting different terms for the adult and embryonic terminal plates, is that, as now understood, the latter includes not only the *lamina cinerea* of anthropotomy, but also the parts afterward differentiated to form the *Columnæ fornicis*, and the *præcommissura*, with perhaps some other parts of the *fornix*.

Hypocampa.—In the paper on Nomenclature (*9*, 125) I stated that this term is employed by Vicq D'Azyr (A) in the descriptions of the plates, although the more common form *hippocampus* occurs in the "List of anatomical terms," in the same work. At that time, I had only seen the passages in the description of pl. vii, fig. 1 and 3 ; pl. viii, fig. 2 ; on p. 61, and elsewhere, where the French form *hypocampe* is used. I have since found several passages, as the descriptions of pl. vi, note, and plate viii, fig. 2, where the Latin forms *hypocampus* and *hypocampi* are given.

Vicq D'Azyr does not discuss the etymology of the term, but says (A, p. 61), the "grande hypocampe" was first mentioned by Arantius and Varolius, whose works are not now accessible to me. Even Hyrtl (A, 180), does not seem aware of the use of the word by Vicq D'Azyr, and all other writers, so far as I know, make it *hippocapmus*. There is no such word as κάμπος, and, if the original orthography cannot be ascertained, *hypocampa* is to be preferred on etymological grounds ; the ridges known as *hippocampus major* and *h. minor* bear no obvious resemblance to the fish known to the ancients as ἱππόκαμπος and *hippocampus*, but the larger of the two, which probably first received the name, does certainly present a most notable *downward curvature*, such as the Greeks might have designated by ὑποκαμπή.

C. A LIST OF SOME POINTS TO BE ELUCIDATED.

No part of the cat's brain is thoroughly or sufficiently understood, and all parts need monographic treatment. The following points, therefore, are selected because the deficiencies in our knowledge of them have been most distinctly impressed upon me.

Albicans.—abn.—Have the *albicantia* the same relation to the Columnæ fornicis which is said to exist in the human brain? What morphical or telical significance has their degree of separation from one another?

Area elliptica. Ar. el.—With what does this correspond in man and the lower vertebrates? If it represents the *oliva* or "olivary body," its position is reversed from that in man in relation to the apparent origin of the N. *hypoglossus.*

Area ovalis.—Ar. ov.—With what does it correspond in man and the lower vertebrates? What are its relations to the several columns of the myelon and metencephalon?

Aula. a. What are its precise limits? In the cat, and other forms with a large *medicommissura*, this commissure may be regarded as its caudal boundary; but in man, where the commissure is smaller, and in the lower vertebrates where it is wholly absent, the question of limitation is more difficult.

Auliplexus.—apx. The plexus which appears near the dorsal end of the *aula* on each side. This plexus is continuous, through the *portiplexus*, with the *proplexus*, and apparently also with the diaplexus, but the relations of the latter are doubtful.

As to the plexuses in general, are they formed as stated by Quain (A. II, 545), and other authors, by the intrusion of the free border of the velum, or of processes thereof, still covered by the endyma, into the various cavities, or as recently stated by Mivart (B, 266)?

"The choroid plexuses of the lateral ventricles are (like those of the third) merely portions of the ependyma, which happen to be very vascular, and are not really intrusions from without."

This statement is so positive that, though unsupported by figures, or detailed description, I forbear to affirm the contrary. So far as I can judge, however, the *proplexuses* are intrusions of the pia, while the *diaplexuses* seem to correspond more nearly with the view of Mivart. In the one case, the fold of velum bears to the fold of endyma the same relation which an abdominal viscus bears to the visceral layer of peritoneum; in the other case, the plexus may be compared to a fold of omentum.

Carina (fornicis).—*ca. f.*—How nearly constant is it, and what is its significance?

Cauda (*striati*).—*cd. s.*—Is it distinct in the cat? Has it the relations described in man by Cuvier (B, III, 51), and others, and more recently and fully by Dalton (*I*, 13)?

Spitzka says (7):—

"I have identified this structure in the cat; it does not make as fine a sweep as in man, but is distinct at the roof of the inferior horn and loses

itself, as has long been known in the case of the human brain, near the *Nucleus amygdalæ*. Prof. Wilder's term is the only admissable one, both as being descriptive and on grounds of priority."

Chiasma.—*ch.*—How complete is the decussation? Of course, microscopic sections must be made, but something might be ascertained by tearing apart the fasciculi after proper treatment to harden the nervous tissue, and soften the connective.

Cimbia.—*cmb.*—Without seeing Gudden's paper, I have assumed that this is the "*tractus transversus pedunculi*" mentioned by Meynert (A, 737). Something of its course after it enters the crus may be seen from microscopic sections; I have not examined its dorsal end.

Commissura fornicis.—*Cs. f.*—Is it constant in the cat, and is it represented in man and other mammals. Is it a true commissure?

Crista (fornicis).—*crs. f.*—What are its histological composition, its function, and its morphical significance? In what other animals does it exist? See my paper (*7*).

Diatela.—*dtl.*—The roof of the "third ventricle." What is its histological composition? What is its relation to the *velum*, or the *pia* in general? How are the diaplexuses connected with it?

Diaplexus.—*dpx.*—Are these formed by the intrusion of the border of the velum, or by only a fold of endyma? See *auliplexus*.

Foramen Magendie.—*Fm. Mg.*—The alleged communication between the metacœlia "fourth ventricle" and the "subarachnoid space." Does it exist in the cat? What are its exact position and form? Is there more than one? Does it permit the passage of liquid in one or both directions?

Flocculus.—*flc.*—Is this represented in the cat?

Hypocampa.—*hmp.*—What is its relation to the fornix and the fimbria?

Insula.—*ins.*—Is the "Island of Reil" represented in the cat by any distinct elevation? If not, what part of the surface corresponds with it?

Interoptici.—*iop.*—Is this pair of lobes, discovered by Spitzka (*4*, *5*, and *11*,) in some reptiles, represented in the cat?

Lyra.—*ly.*—What are its form, extent, connections and manner of formation? Is it in fact a distinct structure, or only a surface?

Metatela.—*mttl.*—The membraneous roof of the "fourth ventricle." What are its form, attachments and histological composition? What are its relations to the *metaplexus*?

Myelon and *metencephalon* (medulla). Leaving their histology out of the question, I have not been able to satisfy myself regarding the relations and nomenclature of the visible components of these parts.

Pia (mater).—*pi.*—Does it consist of one, two, or more layers? What are the relations of its layers to the *Fissura media*, and to the intervals between the cerebellum and hemispheres, and the cerebellum and medulla?

Porta.—*p.*—In my paper (*3*) are given reasons for considering that there are two portæ leading from the mesal aula in the two procœliæ.

Prægeniculatum.—*prgn.*—Is there not some external or structural line of demarcation between the *thalamus* and the *prægeniculatum*?

Pulvinar.—*plv.*—Has this any distinct representative in the cat?

Quadrans.—*q.*—How constant are the inequalities of the surface which enable us, in some cases, to define this area?

Radix intermedia (*rhinencephali*).—*Rx. in.*—Is this ever, in the cat, a distinct root?

Septum lucidum.—*Spt. lu.*—Is there ever, except in man, any space or *pseudocœlia*, "fifth ventricle," between its two lateral halves? Are these halves ever separated by a prolongation of the pia, or only by connective tissue, or are they ever actually fused so that the true nervous tissue is continuous?

Sulcus habenæ.—*Sl. h.*—Is the line of reflection of the endyma from the *thalamus* always along the same line, or at the same distance from the habena?

Tænia.—*tn.*—Is the "*tænia semiculcularis*" a distinct band in the cat? If so, what are its relation with the rima, the proplexus and fimbria?

Terma.—*t.*—(lamina terminalis). What is its histological composition? Shall the name be held to apply also to the very thin portion of the cephalic wall of the *aula* between the *præcommissura* and the *crista*?

Valvula.—*vv.*—The roof of the longer and cephalic part of the epicœlia. Does it consist of true nervous tissue, wholly, or even in part, excepting at the place of attachment of the *NN. trochleares*? Is its ectal surface covered by pia? What histological changes occur at its connections with the *cerebellum* and *postoptici*?

Velum (interpositum).—vi.—What is the relation of this to the folds of pia, and to the thalami and fornix?

D.—EXPLANATION OF THE PLATES.

All of the preparations from which the figures are drawn are in the Museum of Cornell University, and are accessible for examination to those who may desire to verify the figures or the descriptions.

In most cases, each figure is based upon more than one preparation. Encephalotomists need not be reminded of the difficulty of obtaining a preparation which shows many points of structure equally well. Since the present paper is only general, and does not aim to indicate individual peculiarities, or those of sex, breed, or age, most of the figures may be regarded as representing what may be called an *average cat's brain.* It is obvious that a very large number of specimens would need to be carefully compared in order to confer upon any generalization respecting sex, etc., a trustworthy character.

It will be noticed that, excepting when there was some special reason for a contrary course, the figures have been uniformly placed in one of two positions. The symmetrical figures are so placed that the meson corresponds with that of the observer, the two sides being right and left like the observer's eyes. The unsymmetrical figures, representing the lateral or mesal surfaces, natural or in section, are usually so placed that the cephalic end points to the left of the observer.

In a short paper (17) the writer has previously urged the desirability of a uniform position for anatomical figures, and suggested that the head end should be always toward the left. As is stated above, while this seems to be most advantageous for unsymmetrical figures, the symmetrical ones are more easily understood and compared in the position which is usually given them.

The obliquity of fig. 17 was necessary in order to show the *Fissura hypocampæ* in its whole length. That such a position is undesirable, as a rule, may be inferred from the unwonted emphasis with which it was condemned by the late Prof. Jeffries Wyman :—

"The photograph is from an oblique point of view, which I believe people will never learn to be a bad one. If the view had been full front, or full side, or full anything, it would have been better than this."—The American Naturalist, II, 52.

Most of the figures are twice the diameter of the preparations, and, with the exception of figures 1 and 2, it should have been better to make the enlargement four or five diameters. Aside, however, from the greater expense which this would have involved, such a degree of enlargement would have rendered it not only possible but necessary to show certain details of structure upon which my information is, at present, imperfect.

All of the figures have been drawn from my own preparations by Miss G. D. Clements, B. S., at the time a student in the Natural History Course in Cornell University.

Artists and anatomists who have undertaken to represent the details of encephalic structure understand the difficulties of the task, and will admit that the omissions and inaccuracies to which attention is called in the descriptions are both few and unimportant compared with the general thoroughness of the work. Indeed, for all the deficiencies, I hold myself much more responsible than the artist, by whom some of the figures were drawn at least four times, twice upon stone.

PLATE I.

Fig. 1.—The dorsal aspect of the brain. Enlarged two diameters.

The general form and some of the fissures are drawn from prep's 288 and 289, the bisected brain of a white and Maltese ♀ ; but the fissures of the right hemisphere are derived from several different preparations.

The *Lobi olfactorii* (*L. ol.*) are made somewhat too prominent, but there is considerable difference between cats in this respect, although much less than between dogs.

The general features of the *cerebellum* (*cbl.*) are well shown. The *Lobi laterales* (*L. l.*) have only a fair proportion to the median lobe or *vermis* (*vm.*), instead of the preponderance which they have in the human brain. The lateral contortion which characterizes the caudal aspect of the vermis in adult cats (as shown in my paper, 10, 221, pl. i, fig. 1 and 2) does not affect the dorsal part.

Of the *metencephalon* (*mten.*), and *myelon* (*my.*), the following features

are shown: The *Fissura dorsimesalis* (*F. dms.*), or "Posterior fissure;" the dorsilateral fissure (*F. dl.*); the *Columna dorsalis* (*Clm. d.*), and the *Clm. lateralis* (*Clm. l.*); on the right side, the principal trunk of the *N. accessorius* (*N. ac.*), and the dorsal or sensory funiculi of the first spinal nerve (*N. cv. 1.*).

As already stated, the fissures of the hemispheres are differently represented upon the two sides. The combination of the two kinds of fissural arrangement in a single figure serves to illustrate the extent of the lateral variation and compensation to which attention was called by me in 1873 (10, 232).

The postsylvian and supersylvian (*FF. ps.* and *s.*) are represented as united upon the left side, but separated on the other. The junction is more common, but the separation is sometimes complete. The case is somewhat similar with the *lateralis* and *medilateralis* (*FF. l.* and *ml.*). The *ansate* fissure (*F. an.*) presents itself in so many forms that it is difficult to determine its normal condition and connections. It is usually joined with either the *lateralis* or the *coronalis* or both; when separate, it often is triradiate; but occasionally, as in prep. 294, on the left side, it forms a nearly straight fissure at right angles with the lateralis and coronalis, and wholly independent of them both. This condition is represented on the right side of fig. 1. This fissure demands fuller investigation, especially with reference to its representation in the human brain.

So far as I know, the following junctions of fissures which, on some grounds, may be regarded as fissural integers, are constant in the cat: Of the *rhinal* (*rh.*) with *postrhinal* (*prh.*), and of the *sylvian* (*s.*), with the point of their union; of the *superorbital* (*so.*), with the rhinal; of the *callosal* (*cl.*), with the *hypocampal* (*hmp.*), and with the *preradical* (*prrd.*), when it exists.

The following junctions are common: Of the *diagonal* (*dg.*), with the *anterior* (*a.*); of the *postsylvian* (*ps.*), with the *supersylvian* (*ss.*); of the *medilateral* (*ml.*), with the *lunate* (*ln.*), and with the *lateral* (*l.*), or the *confinis* (*cf.*); of the *marginal* (*mr.*), with the *postmarginal* (*pmr.*); and of the *ansate* (*an.*), with the *lateral* or *coronal* (*cor.*), or both.

The junction of the *cruciate* (*F. cr.*), with the *splenial* (*F. sp.*), which Guillot has seen once, Krueg twice (*Krueg*, *2*, 620), and Pansch (*1*), three times out of fourteen, has been observed by me on only four of the many hemispheres examined. I have never seen a union of the *splenial* with the *postrhinal* (*prh.*).

I have never observed the union of the anterior and posterior fissures to form the "first or lowest arched fissure" of the Canidæ. On the other hand, as stated by Krueg (*2*,613), and by myself (11,229), this union sometimes fails with domestic dogs; hence, in this as in many other respects, the cat presents less tendency to vary.

A junction of two fissures is usually marked by a less depth of the compound fissure at that point, constituting a concealed "transition convolution" or "pli de passage," which may be seen by separating the sides or by slicing off the cortex.

Fig. 2.—The sinistral aspect of the brain. From prep. 388. Enlarged two diameters.

The *Lobus olfactorius* (*L. ol.*) is made somewhat too prominent. The curved line upon its lateral surface indicates, approximately, the boundary of the more cephalic portion of the pero or ectal layer, whence arise the *Nervi olfactorii.* These nerves are not shown.

The features of the *Crus olfactorium* indicated by *lm. cin.* and *lm. alb.* are more fully shown upon fig. 3.

The *Nervus opticus* (*N. op.*) projects from the ventral margin of the figure, and the *Fissura Sylviana* (*F. s.*) is seen dorso-caudad of it.

The ventral end of this fissure, as is always the case in the cat, joins the fissure which forms the dorsilateral boundary of the *Tractus olfactorius* (*Tr. ol.*), and the cephalic and caudal divisions of that fissure are called respectively *rhinalis* and *postrhinalis* (*FF. rh.* and *prh.*). So much of the hemisphere as lies caudad of the *F. Sylviana* forms the *Lobus temporalis* (*L. tmp.*), the ventral extremity of which is the *Lobulus hypocampæ* (*Ll. hmp.*).

The cerebellum (*cbl.*) presents the narrow median lobe or *vermis* (*vm.*), and the *Lobus lateralis* (*L. l.*). Near the ventricephalic angle of the latter, two or three of the laminæ of the second tier project as the *Lobulus appendicularis* (*Ll. ap.*), which is seen better in fig. 3.

The *metaplexus* shown in fig. 3 (*mtpx.*), has been removed, so as to expose the prominent *Eminentia auditoria* (*Em. au.*), whence springs the *N. auditorius* (*N. au.*).

Just ventrad of the eminence is the *trapezium* (*tz.*), and cephalad of this is the *pons* (*pn*).

Between the pons and the hemisphere appears a part of the *Crus cerebri* (*Cr. cb.*), and cephalad of this is the slender *N. trochlearis* (*N. tr.*), which, by inadvertence, seems to emerge from the *F. postrhinalis* instead of from between the cerebellum and the hemisphere.

The *N. trigeminus* (*N. trg.*) has been cut short, in order the more clearly to show that it emerges just caudad of the pons, and not through it as in man.

The remaining nerve origins are indicated only by dots. Those of the *NN. glossopharyngeus, vagus* and *accessorius* (*NN. gph., v.* and *ac.*) form a series. At the side of the myelon, near the dorsal and ventral borders, are seen the origins of the first cervical nerve (*N. cr. 1.*).

In this figure the fissures are accurately represented as they are in the preparation, excepting that the small *F. lunata* (*F. ln.*), has been added from prep's 519 and 520. The small *F. intermedia* might well have been inserted between the dorsal ends of the *FF. anterior* and *postica* (*FF. a* and *p*).

Plate II.

Fig. 3.—The *basis encephali*, or ventral aspect of the brain. Enlarged two diameters.

The proportions and general features are from the brain of an adult ♀,

Maltese and white, prep's 288, 289. Some details of the *Area praechiasmatica* (the region cephalad of the chiasma) are from 461 and 527; of the *Ar. postpontilis* (the region caudad of the pons) from 338, 434 and 491, and of the intermediate *A. cruralis* from 422, 506, and 527.

Most of the nerves and cerebral fissures are lettered on the right side, and most of the other parts on the left. Some of the left nerves are cut short, and the left *N. trochlearis* is not shown at all.

The *Lobi olfactorii* (*Li. ol.*), and are made too long, and the *hypophysis* (*hph.*) is too short.

Attention is called to the following points, chiefly in comparison with the human brain :—

The absence of a distinct *Radix intermedia* (*Rx. in.*) of the *Crus olfactorium*, corresponding with the so-called "middle root of the olfactory nerve" in man. The part so designated upon the plate is apparently only an area, comparatively undifferentiated, between the more or less fibrous tracts forming the *Radices mesalis* and *lateralis*.

The turning of the *Rx. mesalis* (*Rx. ms.*) over the margin of the brain so as to appear upon the meson.

The distinction of the *Rx. lateralis* (*Rx. l.*) into a lateral gray and a mesal white tract, the *Limes cinerea* (*Im. cin.*) and the *Lm. alba*.

The great extent of the (*Locus*) *praeperforatus* (*prpf.*), and its division into a cephalic more prominent portion (*Pf. p.*), and a caudal depressed portion (*Pf. d.*). Both portions are "perforated," but the degree of furrowing of the *Pf. prominens* varies considerably. These furrows exist in some other Carnivora.

The width of the *hypophysis* (*hph.*), and the crenation of its caudal border, indicating the existence of an ental subspherical mass, which is covered by an ectal layer, the thinness of which, in the caudal region, permits the contour of the former to be seen.

The slight degree of separation of the *albicantia* (*abn.*), which are here nearly concealed by the hypophysis, but more fully shown in fig. 12.

The distinctness of the *cimbia* (*cmb.*), or "*tractus transversus peduncoli*," which is better seen in fig. 11.

The slight extent of the true *postperforatus* (*ppf.*); the only part which is really "perforated" is a small triangular area just caudad of the albicantia, and partly hidden by them.

The less caudo-cephalic extension of the *pons* (*pn.*); this exposes more of the *Area intercruralis* (*Ar. ic.*) than in man, and uncovers the *trapezium* (*tz.*), which, in man, is wholly concealed. Connected also with this feature of the pons is the fact that the *N. abducens* (*N. abd.*) passes directly cephalad from its origin a little caudad of the pons, whereas in man it is forced to curve around the caudal border. Finally, the *N. trigeminus* (*N. trg.*), in place of emerging through the pons as in man, arises wholly caudad of it, although closely applied to its surface.

The greater extent of the *Ar. cruralis*, which may be ascribed both to

the less extent of the pons, and the less degree of flexure of the whole brain at the mesencephalic region.

The greater width of the *Tractus postrhinalis* (*Tr. prh.*), which includes the surface of the *Lobulus hypocampæ* (*Ll. hmp.*). In man, indeed, this part is hardly visible on account of the prominence of the convolutions laterad of the *F. postrhinalis*.

The apparent origin of the *N. oculomotorius* (*N. ocm.*) laterad of the meson, and just caudad of the cimbia (*cmb.*).

The appearance of a division of the ectal layers of the pontile fibres into three groups, cephalic, caudal and intermediate, the latter partly overlapped by the other two.

The appearance of a faint band crossing the trapezium a little obliquely between the origins of the *NN. abducens* (*N. abd.*) and *facialis* (*N. f.*). The distinctness of this band varies.

The origin of the *N. hypoglossus* (*N. hg.*) laterad of the *Area elliptica* (*Ar. el.*), which might otherwise be taken as the surface of the *oliva* or "olivary body" of man. The determination of this point involves some comparisons and sections which I have not yet made, so I merely indicate the part by a descriptive name and leave the question open.

The close association of the roots of the *NN. glossopharyngeus* (*N. gph.*), *vagus* (*N. v.*), and *accessorius* (*N. ac.*). The long caudal nerve is of course accessorial, and the cephalic funiculi are unquestionably glossopharyngeal; but how the intermediate funiculi should be assigned, I am not yet sure.*

The marked prominence of the ventro-lateral region of the metencephalic continuation of the *Columna lateralis myelonis* (*Clm. l.*), forming an elevation to which I have applied the provisional name *Area ovalis* (*Ar. ov.*).

The absence of any superficial decussation of the *pyramids* (*py.*). Hence, the *F. ventrimesalis* (*F. vms.*) or "anterior fissure," is uninterrupted. The *F. ventrilateralis* (*F. vl.*) is deflected at the caudal end of the *Area elliptica*.

Fig. 4.—The mesal surface of the right half of the brain (hemiencephalon dextrum). Enlarged two diameters.

The general features are from the same brain as fig. 3, but some features are derived from prep's 290, 304 and 454.

The surfaces shown in this figure are of four kinds, as follows :—

1. The natural surfaces which are covered by *pia*. These are the mesal aspects of the *hemisphere* (*hem.*), and the *Lobus olfactorius* (*L. ol.*).

2. The natural mesal surface (*Ar. spt.*) of the right half of the *septum lucidum*, which, in the cat, is in contact with its lateral homologue, or separated therefrom only by a thin layer of connective. I have never observed an interval corresponding to the *pseudocœlia* or "fifth ventricle" of man.

*In a paper on the N. vagus in the cat, presented at the same time with this, Prof. T. B. Stowell has given a fuller account of the relations of these nerves.

3. The natural endymal surfaces of the true *cœliæ* or "ventricles." Of course the "lateral ventricles," procœliæ, do not appear.

4. The cut surfaces of the *commissures* and other parts which cross the meson, or lie upon it. In the *cerebellum* (*cbl.*) the relative areas of the ental *alba* and the ectal *cinerea* forming the *arbor vitæ* (*arb.*), are indicated by the shading; with less definiteness, the alba is shown in the *callosum* (*cl.*), the *fornix* (*f.*), the *præcommissura* (*prcs.*), the postcommissura (*pcs.*), the *commissura habenarum* (*cs. h.*), and the *chiasma* (*ch.*). The section of the *medicommissura* (*mcs.*) should appear as if composed, at least chiefly, of cinerea, but no attempt has been made to indicate the nature of the cut surfaces of the *Crista fornicis* (*Crs. f.*), the *terma* (*t.*), the *hypophysis* (*hph.*), the *infundibulum* (*inf.*), the *basicommissura* (*bcs.*), the *conarium* (*cn.*), the *optici* and *postoptici* (*op.* and *pop.*), the *valvula* (*vv.*), the *Crura cerebri* (*Cr. cb*), the *metatela* (*mtl.*), or the rest of the epencephalon and metencephalon (*mten.*). The extent of the transverse fibres of the *pons* (*pn.*) should have been represented, at least approximately.

So much of the cephalic boundary of the *aula* (A.) as intervenes between the *præcommissura* (*prcs.*) and the *crista* (*Crs. f.*) is very thin, and is too indistinctly shown in the figure. Neither here nor at any other point is there any such interruption of the wall as would form a communication between the true cœliæ and the pseudocœlia or the ectal surface of the brain. It is probable that the presence of such a communication as is ascribed to the human embryo, and to some animals in Quain (A, II, 543), is due to the artificial rupture of the natural connections.

Attention is called to the following points, chiefly in comparison with the human brain :--

The appearance of the *Rr. mesalis* (*Rr. ms.*) on the meson, and the presence of two shallow fissures, *postradicalis* and *præradicalis* (*FF. prd.* and *prrd.*) between it and the adjoining surfaces of the hemisphere.

The large size of the commissures, especially the *medicommissura* which nearly fills the diacœlia (*dc.*).

The non-appearance of the *porta* when the meson is viewed squarely; it is doubtful whether the human "foramen of Monro" is really visible from the meson.

The less extent of the *callosum*, especially of its rostrum (*rm.*). In some human brains the rostrum does not extend so far as is usually represented.

The darker spot on the section of the hypophysis represents the space occupied by the ental mass, which has been removed.

The relations of the pia are not indicated at all, and are not well understood, especially between the cerebellum and the metencephalon and mesencephalon.

PLATE III.

With the exception of fig. 13, all the figures upon this plate represent the natural surfaces of regions which are more or less completely concealed by other parts in the undissected brain.

Fig. 5.—The cephalic aspect of the Prosencephalon after the removal of the *Lobi olfactorii*. From prep. 204. Enlarged two diameters.

The hardened brain was transected at the *FF. postica*, so that the preparation includes only the cephalic two-thirds of the prosencephalon.

The drawing represents the preparation tilted up so as to expose the ventral aspect foreshortened.

As compared with fig. 6, this might well have been made of the natural size. A less regularly symmetrical brain would have been more instructive. One of the *Crura olfactoria* should have been divided at a little greater distance from the prosen.

So far as appears in the figure, the fissures are remarkably alike upon the two sides; the left *F. ansata* (*F. an.*) however, only the meso-cephalic end of which appears in the figure, presents the somewhat unusual but very suggestive condition of entire independence of the *F. lateralis* (which is invisible) and the *F. coronalis* (*F. cor.*). On the right side it is joined by the former fissure.

The right *F. sylviana* (*F. s.*) is shorter than the left, and presents a slight terminal bifurcation which is not shown.

In consequence of the removal of the *Lobi olfactorii*, and the tilting of the whole preparation, so much of the *F. rhinalis* (*F. rh.*) as lies cephalad of its union with the *F. superorbitalis* (*F. so.*) is practically obliterated, and the remainder of it is so foreshortened as to appear as an insignificant intermediate portion of an extensive u-shaped fissure formed by the *FF. sylviana* (*F. s.*) and *superorbitalis* (*F. so.*). The appearances thus presented are suggestive in view of the idea of Meynert (*I*, 12), which I also entertained at one time (10, 225), that the *F. superorbitalis* represents the "anterior branch" of the human *F. sylviana*, and that the intervening part of the brain corresponds to the "operculum."

A slight preponderance of the left hemisphere just caudad of the F. sylviana is somewhat exaggerated in the figure, and the *Crura olfactoria* (*Cr. ol.*) should differ less in form and in their distance from the meson.

The *FF. olfactoriæ* (*F. ol.*) appear as little more than shallow furrows.

On account of the foreshortening of the ventral aspect, the line of separation of the *Portio prominens* (*Pt. p.*) and the *Pt. depressa* (*pt. d.*) is indistinct. The *Ll. hypocampæ* (*Ll. hmp.*) on each side has been flattened by pressure, and is so represented.

Fig. 6.—The caudal aspect of the Prosencephalon, with part of the Diencephalon, after the removal of the other parts of the brain.

From prep. 292, an adult ♀.

The dien. has been transected so as to leave a concave surface which, at the meson, is close to the caudal border of the medicommissura (*mcs.*), but rises at the sides so as to coincide nearly with the caudal surface of the prosencephalon.

The postcommissura has been removed, and the slender transverse band (*Cs. h.*). Just ventrad of the *splenium* (*sp.*) is the *Commissura habenarum*.

Had the postcommissura been left, the intervening space would be a foramen, *Fm. conarii.*

The shallow depression of the ventricaudal surface of each hemisphere just laterad of the splenium, represents the area of contact of the *opticus.*

The cerebral fissures are markedly unsymmetrical, and thus in contrast with those of fig. 5. The right *F. postrhinalis* (*F. prh.*) is the longer, and the right *postsylviana* (*F. ps.*) joins the *F. supersylviana*, although the place of union does not appear in the figure. On the contrary, by reason of the perspective, it seems to be joined by the *F. medilateralis* (*F. ml*).

The *LlLl. hypocamparum* have their proper rounded form in this preparation.

Part of the *diacœlia* (*dc.*) appears dorsad of the medicommissura, and part on its ventral side. In man, the commissure is smaller, and the cœlia correspondingly more extensive. On account of the removal of the hypophysis and infundibulum, the diacœlia opens freely at the *Fm. infundibuli* (*Fm. inf.*).

Fig. 7.—The dorsal aspect of the Diencephalon (thalami and geniculata), and of the Mesencephalon (optici and postoptici).

From preps. 397 and 494, adult ♀♀, 423, a nearly adult ♀, and 506. Enlarged two diameters.

The principal features of this figure were drawn from prep. 506. The preparation was made by lifting the caudal ends of the hemispheres, and gradually separating them, with the callosum, fornix and velum, from the subjacent parts. The epen. and meten. were then removed by a transection just caudad of the postoptici.

The *valvula* (*vv.*) was torn from prep. 506, so it is drawn as it appeared in prep. 494, after inflation by blowing air from the diacœlia through the mesocœlia or *iter.*

The *Commissura habenarum* (*Cs. h.*) is really more distinct in prep. 397 than appears in the figure. The habenæ (*h.*), their sulci (*Sl. h.*) and the lines of reflection of the endyma are taken from prep. 422, and their distinctness is not exaggerated in the figure. Their morphical significance is to be noted in connection with the general question of cœlian circumscription. Upon this point, see a brief note in "Science" (*12*).

The complete roof of the diacœlia, the *diatela* (*dtl.*), is shown in fig. 10.

As compared with the homologous parts in man, the feline *postoptici* (*pop.*) and *geniculata* (*pgn* and *prgn.*) are larger, while the *thalami* (*th.*) seem to be only the mesal continuations of the *prægeniculata* (*prgn.*), and to lack altogether the pulvinar or "posterior tubercle" of man.

Fig. 8.—The caudal aspect of the Mesencephalon, with parts of the adjoining regions. From prep. 506.

The plane of transection coincides nearly with the caudal surface of the *postoptici* (*pop.*), and has divided the *pons* (*pn.*), a little caudad of its middle. The *valvula* (*vv.*) was torn from this preparation, and the line of its attachment is not distinctly shown. Something of its position may be judged from fig. 7. The caudal orifice of the iter or *mesocœlia* (*msc.*) is

shown here as a nearly regular circular spot; in reality, it presents a slight mesal extension at both the dorsal and ventral sides. Indeed, when carefully examined, the so-called "aquæductus sylvii" is far from being a perfectly simple and uniform tube; its form in man is indicated in Reichert's fig. 31 (A, taf. 4). Among the lower mammals it is usually larger, and with the lower vertebrates it often has the proportions of a true cœlia, with lateral extensions.

The *cimbia* (*cmb.*) is partly seen on the right. The *geniculata* (*pgn.* and *prgn.*) do not project as far as they should. The optici are wholly hidden from view by the prominent *postoptici* (pop.).

Fig. 9.—The sinistral aspect of the Mesencephalon and Diencephalon. From preps. 491 and 506. Enlarged two diameters.

The only cut surface shown in this figure is that caused by the oblique transection between the dien. and the prosen.; the plane of section followed the cephalic border of the *Tractus opticus* (*Tr. op.*), and corresponds with the *Sulcus limitans* between the *thalamus* and the *striatum*.

Crossing the *crus* (*Cr. cb.*) just caudad of the *postgeniculatum* (*pgn.*) is seen the *cimbia* (*cmb.*).

The *Nervus trochlearis* (*N. tr.*) had been removed from prep. 506, and was added from prep. 491.

Upon this figure should appear the *Lemniscus superior* and *L. inferior*, and the *postbrachium* and *præbrachium*, provided they exist in the cat as distinct parts visible at the surface. I have not been able to satisfy myself respecting their exact position and limits in the human brain, and refrain from expressing any opinion concerning them.

Fig. 10.—The dorsal aspect of the Diencephalon, including the diatela. From prep. 301, a half grown ♂.

The object of this figure is to show the existence of a *distinct roof of the diacœlia* independent of the velum, which has been removed. This *diatela* (*dtl.*) presents the appearance of something more than the lining endyma, but its structure has not, so far as I know, been examined. The darker triangular area at the cephalic end of the diatela corresponds with the *delta fornicis* (*dlt. f.*).

Fig. 11.—The Area cruralis, with part of the pons and of the Ar. prechiasmatica. Enlarged two diameters. From preps. 506, 425 (nearly adult ♀) and 461 (♂).

So small and so numerous are the parts shown in this figure, that it should have been yet more enlarged.

The *Lobi temporales* have been divided at different levels on the two sides. From the right, only the extremity, or *Ll. hypocampæ*, has been removed, and the section of the *medicornu* (*mcu.*) which is here cut very obliquely, is a slightly curved space completely circumscribed by a nervous wall. Neither in the cat, nor—contrary to the common belief and the explicit statement in Quain, A, II, 543, 544—in man, does the *rima* or "great transverse fissure" extend to the *tip* of the medicornu.

Where the *Ll. hypocampæ* rests against the *Tractus opticus* (*Tr. op.*),

there is usually a deep notch which may be called the *Incisura hypocampæ* (*Inc. hmp.*).

On the left side, the hemisphere was dissected off so as to leave two cut surfaces. One of these surfaces is plane and nearly horizontal, and lies at about the level of the dorsal end of the *postgeniculatum* (*pgn.*). The other is convex, and extends from the cephalic border of the former obliquely to the ventral surface of the brain ; it corresponds closely with the cephalic border of the *Tractus opticus* (*Tr. op.*).

The left *medicornu* is cut at about the middle, and at nearly a right angle with its course ; hence its lumen presents its characteristic crescentic section, the ental boundary being the convex surface of the *hypocampa* (*hmp.*).

The cephalic margin of the medicornu is here seen to reach the surface of the hemisphere close to the *Tractus opticus*, and this narrow line of interruption of the true nervous wall of the cornu constitutes the *rima*. The scale upon which this figure was drawn did not permit the relations of the *pia*, the *velum*, and the *proplexus* to be shown, and the undulations of the ectal surface, corresponding with the *FF. hypocampæ* and *fimbriæ*, and the *fasciola* and *fimbria* are hidden by the projecting postgeniculatum.

Most of the cephalic portion of the brain has been removed, but the *Portio depressa* (*Pt. d.*) of the *præperforatus* is seen, with part of the *Pt. prominens* (*Pt. p.*). The removal of most of the *chiasma* (*ch.*) exposes the form and extent of the *Recessus opticus* (*R. op.*).

The *pons* has been transected obliquely, and its caudal portion removed together with the rest of the epen. and the metencephalon.

The left *Crus* (*Cr. cb.*) is seen in its whole length, excepting a small part concealed by the slightly projecting cephalic border of the pons. The well-marked *cimbia* (*cmb.*) may perhaps be regarded as the boundary between the diencephalic portion of the crus (*Pt. dien.*) and the mesencephalic portion (*Pt. msen.*), which more directly supports the *optici* and *postoptici;* in man, this part seems to be almost wholly concealed by the pons.

The right *N. oculomotorius* (*N. ocm.*) is seen to emerge from the crus just caudad of the mesal end of the cimbia, and just laterad of the *Sulcus intercruralis lateralis* (*Sl. ic. l.*). A marked longitudinal ridge of the crural fibres separates from the *postgeniculatum* (*pgn.*) the depressed area which. from its forming approximately the fourth of a circle, I have called the *quadrans* (*q.*).

The *albicantia* (*abn*) are more closely united than in man, but they are large, white, and perfectly distinguishable. The shallow furrow between them, together with the u-shaped furrow which forms their cephalic boundary, may be named *Sulcus triradiatus* (*Sl. trd.*).

The hypophysis has been removed so as to expose the *Tuber cinereum* (*T. cin.*), and the thin raised margin of the *Fm. infundibuli* (*Fm. inf.*).

Just caudad of the albicantia, and partly overhung by them, is a small triangular depressed space with distinct perforations; this seems to be the true *postperforatus* (*ppf.*).

The entire *Area cruralis* may be more completely exposed by removing the cerebellum and dorsiducting the medulla, as in prep. 425.

Fig. 12.—The dorsal aspect of the Metencephalon or Medulla, showing the metatela or roof of the metacœlia. From prep. 397, adult ♀, 464 and 491.

The metatela here shown is apparently independent of the *pia;* like the diatela it seems to consist of more substantial tissue than simply endyma, but I am not aware that its microscopic structure has been ascertained. I am in doubt respecting the precise limits and attachments of the metatela, and the form and location of the "foramen of Magendie." Hence the figure is vague and unsatisfactory upon these points.

Fig. 13.—Part of an oblique transection of the Prosencephalon and Diencephalon to show the form and position of the *crista*. From prep. 441. Enlarged two diameters.

The brain was transected obliquely at an angle of about 45 degrees with the general longitudinal axis. The plane of section passed from a point nearly dorsad of the genu, through the aula, the medicornua and the albicantia. The figure includes only a part of the caudal aspect of the slice.

The dorsal borders of the hemispheres are divaricated slightly, and the *callosum* (*cl.*) is seen crossing the interval; the slight notch on each side just dorsad of the callosum is the *F. callosalis* (*F. cl.*).

The *striata* (*s. s.*) are seen in section just ventrad of the lateral expansion of the callosum, while the lower part of the figure is occupied by the thalami (*th*), united by the *medicommissura* (*mcs.*). Between each thalamus and the corresponding striatum is a groove, the *Sulcus limitans* (*Sl. li.*).

The *Columnæ fornicis* (*Clm. f.*) are divided nearly at a right angle with their course, and at a point just dorsad of the *crista* (*crs. f.*), which is particularly well shown in this preparation. The open space between the fornix and the thalami is the *aula* (*a.*), and on each side are the *portæ* (*p.*) leading into the *procœliæ*. All the plexuses have been removed.

PLATE IV.

Unlike those of Plate III, all of the figures upon this plate represent cut surfaces, although some natural surfaces are shown also.

Fig. 14.—A ventricaudal view of the *fornix*, with the adjacent parts. From prep's. 507, 463 and 396 (adult ♂). Enlarged two diameters.

The preparations were made while the brain was fresh, so as to permit more flattening of the hemispheres, and consequent exposure of the fornix.

After the removal of the rhinen., meten., epen. and mesen., the thalami and geniculata were excavated piecemeal, so as not to injure or displace the fornix. The cut surface (*s.*) at each side of the fornix (*f.*) is the plane of division of the dien. from the striatum.

The cephalic end of the prosen was then sliced down to the level of the *præcommissura* (*prcs.*), which is seen to send a distinct fasciculus toward the rhinen. on each side. Then the right hemisphere was sliced obliquely

from near the meson dorso-laterad so as to cut the *medicornu* (*mcu.*) and *hypocampa* (*hmp.*) at about the middle of their length. On the left side. the *L. temporalis* was allowed to fall somewhat by its own weight so as to expose the fornix more fully.

The *velum* and all the *plexus* were removed so as to display the peculiar markings of the fornix and its mesal portion which is supposed to represent the *lyra* (*ly.*).

The *portæ* (*p.*) appear both shorter and narrower than they really are, on account of the obliquity of their planes to the line of vision. The v-shaped line called *ripa* (*rp.*) which connects the two portæ, separates the *delta* (dlt.) or entocœlian part of the fornix from the remaining surface, which is wholly outside of the cœlian cavity. The delta forms the roof of the *aula*, the cephalic continuation of the diacœlia between the two portæ, and the ripa is the line of reflection of the *endyma* upon the two *auliplexus;* the removal of these plexuses causes the rupture of the endyma along the ripa.

At each side, the ripa curves dorsad somewhat sharply so as to reach the dorsal end of the porta; at this point, and dorso-caudad for the entire length of the *rima* (*r.*), the endyma is simply reflected from the contiguous surfaces of the *fimbria* (*fmb.*) and the corresponding border of the *striatum.* Hence the rima is virtually *closed*, and thus wholly distinct from the porta.

On the meson, between the portæ, is seen the *crista* (*crs. f.*), which is unusually rounded in this preparation. The *carina*, which sometimes appears as a slight mesal ridge extending dorso-caudad from the crista, does not appear in this preparation. The *Recessus aulæ* (*R. a.*) is the cleft between the two *Columnæ fornicis* (*Clm. f.*) whose cut ends are seen just caudad of the præcommissura. The shading on the caudal aspect of the columnæ indicates, but rather too distinctly, a slightly depressed area, of which the dorsal part, close to the crista, sometimes presents the appearance of a transverse band, for which I suggest the name *Commissura fornicis* (*Cs. f.*).

After a prolonged examination of many preparations, I am unable to define accurately the limits of the fornix and the *lyra* (*ly.*). A comparison of the accounts given in standard works with the appearances presented by the limited materials at my disposal, leads me to doubt whether the relative extent of the two parts in the human brain is well determined.

The *fasciola* (*fscl.*) is thick, and no part of it presents the denticulations from which its more ventral portion, in man, is called "fascia dentata." The peculiar curve of the hypocampa, medicornu and fasciola is well indicated by the fact that the *F. hypocampæ* (*F. hmp.*), which corresponds nearly with them in direction, is visible in this preparation only at its two ends, near the *splenium* (*sp.*), and near the tip of the *Ll. hypocampæ* (*Ll. hmp.*). Between the fimbria and the fasciola is a depressed line which may be called the *Fissura fimbriæ* (*F. fmb.*).

Fig. 15.—The dorsal aspect of the *procœliæ*, with their *proplexus*. From prep. 465. Natural size.

The especial object of this preparation is to show that, in the cat, *no part of the thalamus appears in the procœlia.* The cerebellum (cbl.) is shown only in outline.

Both hemispheres were sliced from the dorsum to the level of the intermediate part of the *callosum* (*cl.*). This laid open both procœliæ in some degree. The central part of each procœlia is sometimes called *cella media* (*cel. m.*). The right medicornu was then opened to the tip which, however, cannot be seen from the dorsal side.

The floor of the procœlia is seen to be formed by the *striatum* (*s.*), the *fornix* (f.), and the *hypocampa* (hmp.). The proplexus have been turned in opposite directions for the sake of showing the absence of any interval between the fornix and hypocampa—or the fimbria which forms the border of the latter—and the striatum, such as would permit the appearance of the thalamus in the procœlia. Whatever may be the case in man, neither in the cat nor in any other mammal examined by me, is there any separation of the borders of the rima more than will permit the intrusion of the border of the velum to form the proplexus.

It is commonly stated in works upon human anatomy that the thalamus appears in the "lateral ventricle," forming part of its floor. It is possible that the narrowness of the human fornix may permit this to occur; but the part of the thalamus so appearing must be covered by endyma, and should be so described in contradistinction to the larger portion of its dorsal aspect, which is certainly ectocœlian. However this may be in man, it is not the case in any other mammal examined by me, and the explicit statement in both the French and the English editions of Chauveau's "Anatomy of domesticated animals," that the thalami appear in the lateral ventricles in the horse, ox, pig and dog, and, by implication, all other members of their several groups, should not be accepted without definite descriptions and figures.

Fig. 16.—From preps. 425 and 493. Enlarged two diameters.

This figure shows the *continuity of the procœlia with the rhinocœlia,* and its *communication through the porta with the aula and diacœlia.*

The right half of the brain was transected through the caudal part of the *medicommissura* (*mcs.*). A slice was then cut from the mesal aspect so as to include the *genu.* This exposed the *præcornu* (*prcu.*) with the mesal aspect of the *striatum* (*s.*), the *rhinocœlia* (*rhc.*), and the relative extent of the *pes* (*ps.*), and the *pero* (*po.*) of the *Lobus olfactorius.* A *bristle* was then passed through the *porta* from the præcornu into the *aula* (*a.*). Just ventrad of the bristle are the *præcommissura* (*prcs.*), and the *terma* (*t.*). The latter is traced distinctly to the *chiasma* (*ch.*), so that the cephalic wall of the cœlian cavity is complete. The deeper shadow just dorsad of the chiasma indicates the position of the *Recessus opticus* (*R. op.*).

Just dorsad of the bristle, the *crista* (*Crs. f.*) is seen divided upon the meson, and continuous with the *Columna fornicis* (*Clm. f.*). The indentation between the crista and the præcommissura corresponds with the *Recessus aulæ* (*R. a.*). The triangular *Area septalis* (*Ar. spt.*) between the

fornix and the callosum, is the mesal surface of the right half of the *Septum lucidum* (*Spt. lu.*) and is in contact with its *platetrope* or la... homologue in the undissected brain. The thickness of the lateral lam... constituting the septum render the adjective *lucidum* wholly inapplic...

Fig. 17.—The mesal aspect of the right hemisphere, with the L... olfactorius. From prep's 296 and 401.

The caudal divisions of a half-brain were removed, and the thalam... carefully excavated so as to leave undisturbed the *fornix* (*f.*) and ... *fimbria* (*fmb.*). In this respect, this figure may be compared with ... left half of fig. 14.

The special object of this figure is to show the *F. hypocampæ* (*F. h*...) in its whole length at once. So great is the curvature of the parts ... this is possible only in a single position of the preparation in which ... meson is foreshortened. In general, this figure may be compared w... those given by Flower (13) of the rabbit and sheep.

The dorsal end of the *F. hypocampæ* is seen to turn sharply around ... *splenium* (*sp.*), so as to become continuous with the *F. callosalis* (*F. c*...). The *fasciola* (*fscl.*), is wide, and devoid of denticulations, but is cro... obliquely by a shallow furrow. In this position of the preparation. ... *F. fimbriæ* (*F. fmb.*), appears to be continuous with a short line pass... cephalad to a point ventrad of the callosum ; in reality, however, this la... line is only one of the markings of the ventral surface of the fornix, a... the *F. fimbriæ*, like the *F. callosalis*, turns sharply dorso-caudad to term... nate just cephalad of the splenium.

Fig. 18.—The *right procœlia* seen from the right or ectal side. Fr... prep. 495.

The right half of the brain was removed in successive slices until w... remained was about 3 mm. thick. The remainder of the *striatum* w... then everted from the *præcornu* (*prcu.*). The *proplexus* (*prpx*) is sligh... displaced, but the *porta* is hidden by the *portiplexus* (*ppx.*). The m... cornu (*mcu.*), and the *hypocampa* (*hmp.*), are shown in section, and ... other parts will be readily recognized. The relative heights of th... *opticus* (*op.*), and the *postotpicus* (*pop.*) at a little distance from ... meson are well displayed. The short curved line at the cephalo-vent... end of the procœlia represents the beginning of the passage to the rhin... cœlia.

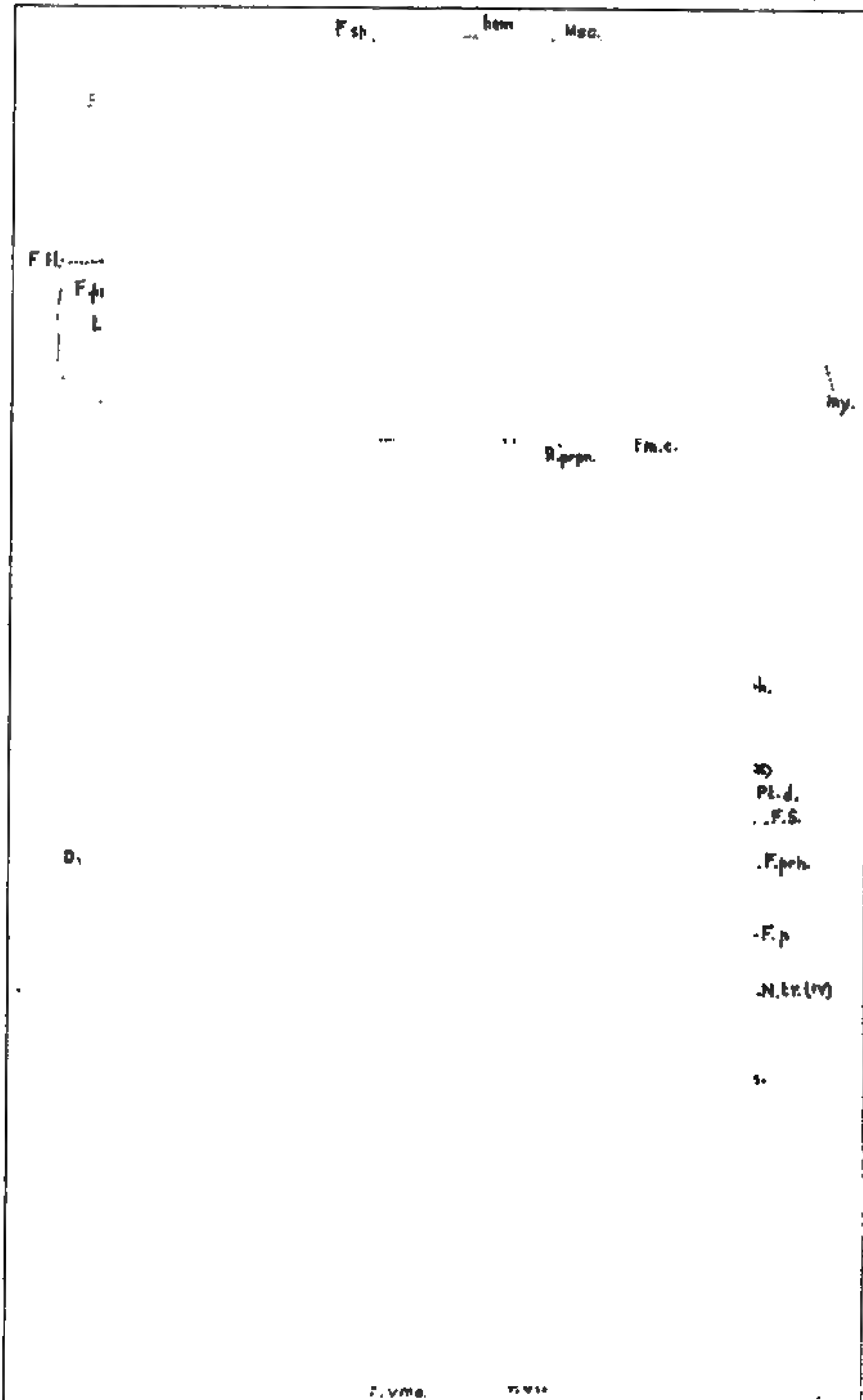
Fig. 19.—The *left præcornu* and *porta* exposed from the left or ec... side. From prep. 495.

This figure represents the other side of the same brain as that fr... which Fig. 19 was drawn. The preparation was made in the sa... way, but in addition the proplexus and portiplexus were carefully snipp... off so as to expose the porta.

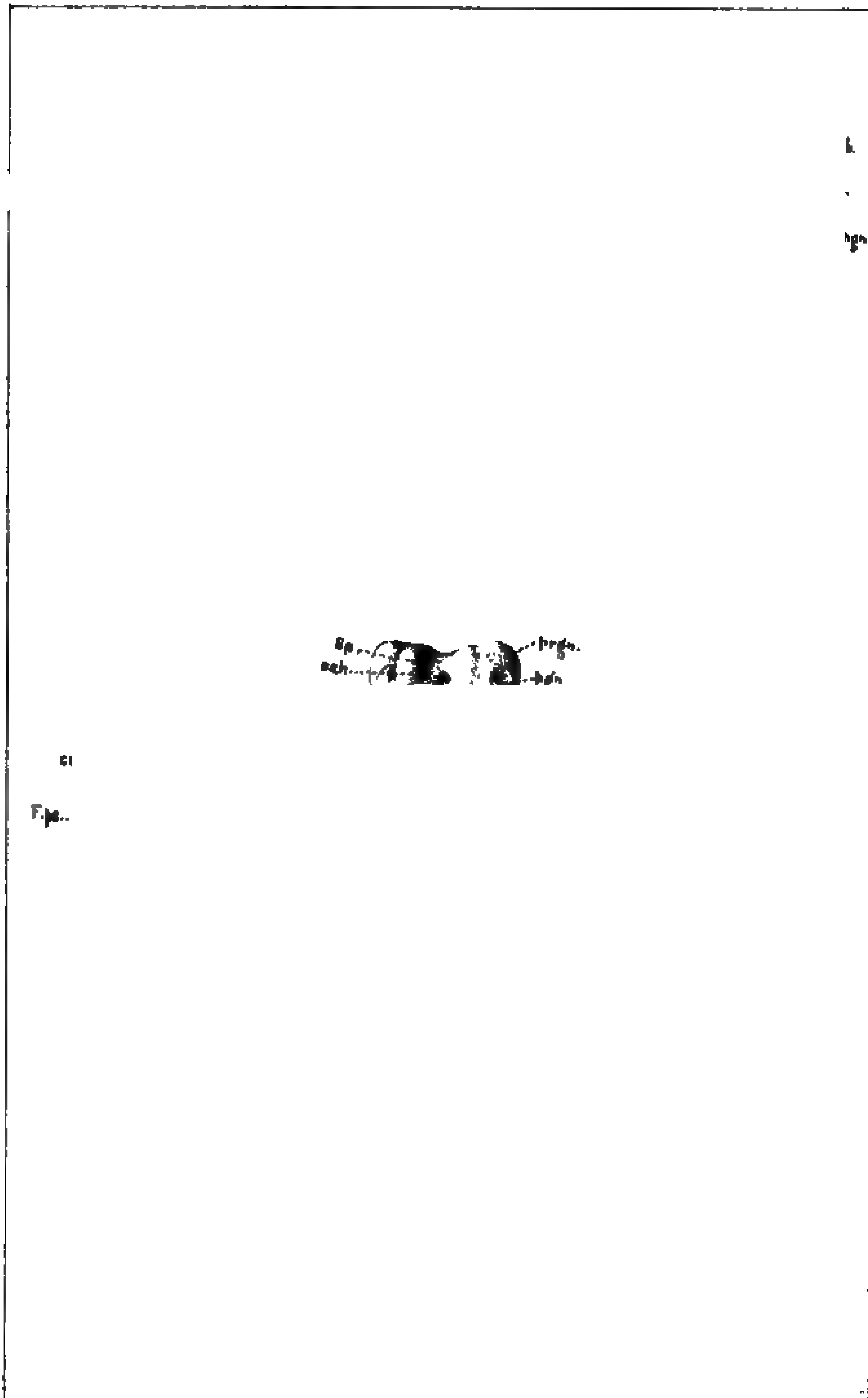
The *porta* (*p.*) is seen to open between the *Columnæ fornicis* (*Clm. f.* ...) the cephalic end of the *thalamus* (*th.*). The orifice would appear larg... the preparation had been so placed as to leave its plane parallel with ... picture-plane.

PLATE I

chS.hem



WILDER ON BRAIN OF CAT



MILLER ON BRAIN OF CAT

WILDER ON BRAIN OF CAT

The membranes could not be shown well on so small a scale. In this and in the previous figure the fornix is seen to be continuous with the *Septum lucidum* (*Spt. lu.*) which forms part of the mesal wall of the *præcornu*.

Fig. 20.—Transection of the *fornix* with the *crista*. From prep. 508.

The object of this figure is to show the decided elevation formed by the *Crista* (*Crs. f.*). Only enough of the rest of the section is included to locate the crista.

LIST OF WORKS AND PAPERS REFERRED TO.*

Barclay, John.—A.—A new anatomical nomenclature, relating to the terms which are expressive of position and aspect in the animal system. O. pp. 182, 5 plates. Edinburgh, 1808.

Chauveau.—A.—Traité d'Anatomie comparée des Animaux domestiques. seconde edition, O., pages 992, 368 figs. Paris, 1871.

Cleland, J.—*I*.—A remarkable double monstrosity of the head. Journ. Anat. and Phys., XIII, 164–172 ; 2 plates. 1879.

Clevenger, S. V.—*3*.—Plan of the Cerebro-spinal nervous system. Read before Am. Assoc. for Adv. Sci., 1880. Jour. of Nerv. and Mental Disease, Oct., 1880. Pp. 40, 26 figures.

Cuvier, G.—A.—Leçons d'Anatomie comparée. 2me edition, 8 vols., D. Paris, 1835–1846.

Dalton, J. C.—*I*.—Cerebral Anatomy, with special reference to the Corpus Striatum. Annals of the Anatomical and Surgical Society, II, 1–18, 6 figures. Jan. 1880. Reprinted in "Brain."

Dunglison, R.—A.—A Dictionary of Medical Science. Large O., pages 1131. Philadelphia, 1874.

Flower, W. H.—13.—On the Commissures of the Cerebral Hemispheres of the Marsupialia and Monotremata as compared with those of Placental mammals. Phil. Trans. clv., 1865, 633–651, 4 plates. Abs. in Roy. Soc. Proc. xiv., 1865, 71–74.

Foster and Langley.—A.—A Course of Elementary Practical Physiology. 3d edition. D., pages 276. London, 1878.

Gegenbaur, C.—A.—The Elements of Comparative Anatomy. Translated from the German by F. J. Bell. Edited by E. R. Lankester. O., pp. 45, 35 figures. London, 1878.

Huxley, T. H.—A.—Manual of the Comparative Anatomy of Vertebrated Animals. D., pages 431, 110 figs. New York, 1872.

———70.—On the Brain of Ateles Paniscus. Zool. Soc. Proc., 1861 ; 247–260 ; 1 plate, 2 figures.

———*1*.—On the Evolution and Classification of Mammals. Zool. Soc. Proc., 1880. Reported in "Nature," Jan. 6 and 13, 1881.

Hyrtl.—A.—Onomatologia, etc. O., pp. 626. Wien, 1880.

Krueg, J.—*2*.—Ueber die Furchen auf der Grosshirnrinde der zono-

* For the manner of reference, see the note at the beginning of this paper.

placentalen Saugethiere. Zeitschrift für wiss. Zoologie, xxxiii, heft 4, 1880.

Leuret et Gratiolet.—A.—Anatomie comparée du systeme nerveux considéré dans ses rapports avec l'intelligence. 2 vols., O., 1284 pages, with folio atlas of 32 plates. Paris, 1839, 1857. (Vol. I is by Leuret, Vol. II. by Gratiolet as stated in a note appended to the explanation of pl. xvii, plates i—xxii were drawn and engraved under the direction of Leuret: but the explanations of xvii–xxii were prepared by Gratiolet according to Leuret's method; the remaining plates were prepared under the direction of Gratiolet.)

Morrell, G. H.—A.—Supplement to the Anatomy of the Mammalia. Containing dissections of sheep's heart and brain, rat, sheep's head, and ox's eye. O., pages 269. London, 1872.

Meynert, T.—A.—The Brain of Mammals. In Stricker's Histology.

———.*1*.—Die Windungen der convexen Oberfläche des vorderhirns bei Menschen, Affen und Raubthieren. Archiv für Psychiatrie, etc., vii, 1877.

Mivart, St. George.—A.—The common frog. Nature series, London. 1874. D., pp. 158, 88 figures.

———.B.—The Cat; its History, Anatomy, Psychology and Origin, an Introduction to the study of Backboned Animals, especially Mammalia. O, pp. 557, 200 illustrations.

Monro, Alexander, *secundus*.—A.—Observations on the Structure and Functions of the Nervous System. Illustrated with tables. F., pp. 176, 47 plates. Edinburgh, 1783.

Owen, R.—A.—Comparative Anatomy and Physiology of Vertebrates. O., 3 volumes, 2155 pages, 1471 figures. London, 1861, 1868.

Pansch, A.—*1*.—Beiträge zur morphologie des Grosshirns der Saügethiere. Morphologische Jahrbuch, v, 1879.

Quain.—A.—The Elements of Anatomy. 8th edition, 2 vols., O., pages 1530, 1000 figures. London, 1877.

Reichert, C. B.—A.—Der bau des menschlichen Gehirns. Zweite Abtheilung. O., pages 192, 9 plates and 10 figs. Leipzig, 1861.

Rolleston, G.—B.—The Harveian Oration for 1873. D., pp. 90, 4 figures. London, 1878.

Solly, Samuel.—A.—The Human Brain, its Configuration, Structure, Development, and Physiology; illustrated by references to the nervous system in the lower orders of animals. D., pp. 492, 2 figures, 12 plates. London, 1836.

Spitzka, E. C.—*1*.—The central tubular gray. Jour. of Nerv. and Mental Disease; April, 1880; pp. 40.

———*2*.—Notes on the Anatomy of the Encephalon, especially the larger ganglia. "Science," II, 14. Jan. 15, 1881.

———*3*.—The peduncular traits of the Anthropoid apes. Jour. of Nerv. and Mental Disease, pp. 27. July, 1879.

———*4*.—The higher Ganglia of the Mid and Hind Brain. Jour. of Nerv. and Mental Disease. July 1880.

———*5.*—The Brain of the Iguana. Ibidem. Reprinted in "Science," Aug. 14, 1880, 73, 74.

———*6.*—The Architecture and Mechanism of the Brain. Preliminary considerations. Jour. of Nervous and Mental Disease, 1878.

———*7.*—Letter to the Editor on the Nomenclature of the Brain. "Science," April 9, 1881; 165, 166.

———*9.*—Contributions to Encephalic Anatomy, part 10. Jour. of Nervous and Mental Disease, vii, No. 2. April, 1881.

———*10.*—Notes on the Architecture of the Oblongata. N. Y. Med. Jour. and Obstet. Review, Sept. 1881; pp. 10, with one plate.

———*11.*—Some new features of the corpora quadrigemina. The Medical Record, Mar. 13, 1880; 282–284.

———*12.*—Notes on the anatomy of the encephalon, notably of the great ganglia. "Science," Jan. 15, 1881, 14, 15.

———*13.*—Further notes on the brain of the Iguana, and other Sauropoida. "Science," Feb. 19, 1881, 75, 76.

Straus-Durckheim, Hercule.—A.—Anatomie descriptive et comparative du chat, type des mammifères en general, et des carnivores en particulier. 2 volumes, O., 1020 pages, with folio atlas of 25 plates. Paris, 1845.

Vicq d'Azyr.—A.—Traité d'Anatomie et de Physiologie avec des Planches coloriées représentant au Naturel les divers Organes de l'Homme et des Animaux. F., p. 1. Paris, 1786.

Wilder, Burt G.—11.—The outer cerebral fissures of Mammalia (especially the Carnivora) and the limits of their homology. Amer. Assoc. Proc., xxii, 1873, 214–234, 19 figures.

———12.—Cerebral variation in domestic dogs and its bearing upon scientific phrenology. Amer. Assoc. Proc., xxii, 1873, 234–249, 7 figures.

———17.—The need of a uniform position for anatomical figures. Amer. Assoc. Proc., xxii, 1873, 274.

———*2.*—The anatomical uses of the cat. N. Y. Med. Jour., Oct. 1879, pp. 16.

———*3.*—The foramina of Monro: some questions of anatomical history. Boston Med. Surg. Journal. CIII., Aug. 12, 1880. 2 pages.

———*4.*—Notes on the anatomy of the cat's brain. Read at the meeting of the Amer. Assoc. Adv. Science, 1879.

———*5.*—On the foramina of Monro in man and the domestic cat. Read at the meeting of the Amer. Assoc. Adv. Science, 1880. Partly reported in the Boston Daily Advertiser, Aug. 30, 1880. The N. Y. Medical Record, Sept. 18, 1880.

———*6.*—A partial revision of the nomenclature of the brain. (Same as No. 6.)

———*7.*—On the Crista fornicis, a part of the mammalian brain, apparently unobserved hitherto. (Same as No. 6.)

———*8.*—The cerebral fissures of the domestic cat, *Felis domestica.* "Science," I, No. 5, 49–51; 2 figures. July 31, 1880.

———*9.*—A partial revision of anatomical Nomenclature, with especial

reference to that of the brain. "Science," II, No. 38, 122–126, No. 39, 133, 138. Mar. 19 and 26, 1881.

———*10.*—The two kinds of vivisection, sentisection and callisection. Medical Record, Aug. 21, 1880, 219. Reprinted in "Nature," Sept. 30, 1880, and in "Science," Oct. 23, 210.

———*11.*—How to obtain the brain of the cat. "Science," II, No. 41, April 9, 1881, 158–161.

———*12.*—Criticism of Spitzka's "Notes on the anatomy of the encephalon. etc." "Science," No. 31, p. 48, Jan. 29, 1881. (Embodies a statement of opinion as to the dorsal limits of the diacœlia.)

———*13.*—On the brain of a cat lacking the corpus callosum. (Presented at the meeting of the Amer. Assoc., 1879, but not yet published.)

Williams, H. S.—A.—The bones, ligaments and muscles of the domestic cat. O., pp. 86; with atlas of 12 folio plates. Copies, reduced one-third, of the outline plates in Straus-Durckheim's A. The text is an explanatory index. New York, 1875.

Addenda.—Concerning the morphical relations and significance of the *conarium* and the *hypophysis*, see the paper by Prof. Owen, read before the British Association in 1881, and reported in "Nature" for Sept. 22, 1881.

In his Report for 1880, as Entomologist of the U. S. Dept. of Agriculture, my colleague, Prof. J. Henry Comstock, expresses (p. 284) his approval of most of the toponomical terms proposed in the present paper (p. 531) and employs them in the descriptions of insects therein contained.

Stated Meeting, November 4, 1881.

Present, 12 members and 7 visitors.

President, Mr. Fraley, in the Chair.

Mr. Barbour a newly-elected member was introduced to the President, and took his seat.

Letters accepting membership were received from Mr. Charles J. Jones, Jr., dated Augusta, Georgia, October 26; from Mr. Jedediah Hotchkiss, dated Staunton, Virginia, October 31; from Prof. C. L. Doolittle, dated South Bethlehem, Pennsylvania, October 28, and from Prof. Mansfield Merriman, dated Bethlehem, Pennsylvania, October 25.

Letters of acknowledgment were received from the Physical

Society, Berlin (103–105); the K. L. C. German Academy, Halle (sets of Transactions and Proceedings); the Prague Observatory (XVIII, 107); Offenbach Verein (XVIII, 107); Physical Society, Geneva (102–105); Swiss Society, Bern (102–105); Royal Society, Luxembourg (103–105, 106, 107, List); Royal Society, London (105, 106, List); Victoria Institute (107, 108); Literary and Philosophical Society, Liverpool (106, List).

Letters of envoy were received from the Physical Society, Berlin; Saxon Society, Leipsig; L. C. Academy, Halle; Swiss Society, Bern; Physical Society, Geneva, Musée Guimet, Lyons; Zoological Society, Paris; Geological Survey of India; and Department of the Interior, Washington.

Donations to the Library were received from the Academies at Halle and Brussels; the Com. Geog. Society, Bordeaux; Annales des Mines; Revue Politique; London Royal, Zoological, Geographical, Geological, Meteorological and Asiatic Societies, and Nature; Mr. Sanford Fleming; the Canadian Journal; Dr. Green of Groton; Silliman's Journal; New Jersey Historical Society; Medical News; A. R. Spofford of Baltimore, and the U. S. Department of the Interior.

Dr. Ruschenberger declined by letter his appointment to prepare an obituary notice of the late Dr. B. H. Coates, on account of his engagements.

Dr. Brinton communicated by letter a paper "On the names of the gods in the Kiche myths," the reading of which was postponed to the next meeting.

"The paper is an exegetical study of the celebrated myth of the Kiche tribe of Guatemala, known as *Popol Vuh*, or National Book. The original dates from the latter half of the XVI century, and was first published in Paris by the Abbé Brasseur de Bourbourg in 1861. The facilities I have had for its study have been principally the MSS. grammars and dictionaries of the Guatemalan tongues presented to the Society by Señor Mariano Galvez, President of Guatemala, in 1836. Their use has thrown new and important light on the significance and character of this myth; and, as these MSS. have never been published, I have given numerous full extracts from them. The treasures of the Library of the Society will thus be brought to the knowledge of students."

Dr. Newberry communicated, by letter, of October 27th, a paper "On the Origin and Drainage of the Great Lakes," the reading of which was postponed to the next meeting.*

Dr. E. R. Heath, present by invitation, was then presented by Prof. Cope to the President, and requested to describe the manner and results of his recent exploration of the river Bene, and the hitherto unexplored regions of Bolivia, lying to the south west of the railroad now being built alongside of the rapids of the Madeira river.

Dr. Heath exhibited a wall map of the north east course of the Bene river through the great periodically inundated plains, which stretch between the east foot hills of the Andes, and the mountains of Brazil, down to its junction with the Mamora (coming from the south) to form the Madeira

He exhibited also a collated map of the water system of the Upper Madeira waters, and described the corrections necessary to be made on the published maps of Bolivia.

He described the vast forests of rubber and Brazil nut trees—trees of 200' height when mature the pampas, scattered over with shrubs like our scrub oaks the channel of the Bene, straight as a whole, but tortuous in detail, with alluvial banks, about 30 feet high, over or through which, every year, the inundation spreads over the whole country, leaving here and there dry spots on which the Brazil nut grows the solitary obstacle to navigation, in the shape of low gneissoid rocks, not far above its junction with the Madeira and the commerce in gold, silver, copper, tin, fine coffee, cocoa, vanilla, caoutchouc, Brazil nuts, cattle, &c., which will some day flourish, by the natural route of the Bene, Madeira and Amazons, opening up Bolivia to the civilized world.

For 800 miles the Bene is navigable, without interruption, by steamboats drawing 5 feet of water.

Dr. Heath described the various tribes of the country ; one, as white as Europeans, and another addicted to cannibalism, and greatly dreaded along the river, on account of their occasional raids for the purpose of securing victims. Neighboring tribes present the most diverse facies. In one district a tribe of small men adjoin a tribe of very tall full bodied men, and next to these live a tribe of tall, meagre and cadaverous men All three of these tribes speak different languages. Dr. Heath intends to make a comparative study of his copious linguistic notes.

He exhibited several sheets on which were his drawings of some of the very numerous symbols, or picture writing, which have been cut, to a depth of about an inch, probably by the architectural race of Cuzco and lake Titicaca, on all the rocks in and alongside of the river channels, in the district around the great forks of the Madeira. He believed these inscrip-

* This paper will be printed in Vol. xx, No. 111.

tions to relate to the navigation of the river, because of their situations above, below or at the water level, during the various stages of low. middle or high water. Wherever they occurred at dangerous points, he noticed that duplicates were cut so as to face both descending and ascending boats, and the relation of certain marks to safe low water at such and such a point was evident.

It is probable then that the Bene was used in the pre-Spanish age by the race which has left its noble monuments not only on the plateau between the two Andean ranges, but in the ravines by which the head waters and branches of the Madre de Dios and Bene descend into the plain. He could not find, nor hear of, any architectural remains on the plain itself; but he was informed that a "fort" stood on an island in a lake which occupies part of the triangle between the Bene on the northwest and the Mamora on the east.

The plain itself is astonishingly level, the upper reaches of the Bene being only 600 or 700 feet above sea level. [In giving his own exact determination from observations with the mercurial barometer (and supplementary aneroids) extended through three years at El Paz, he remarked on the falsity of former determinations made during transient stops in the country; one well known point being put variously from 170 feet *below*, to 1700 feet *above* tide. This he explained was due to the fact that while the mercurial column is not subject to ordinary fluctuations, and seems for weeks at a time to be quite or almost stationary, there is really a steady cyclical rise for six months, and a corresponding steady fall for the other six months of each year, and this must be taken as the basis of all meterological and hypsometrical investigations].

Dr. Heath then described in a general way the zoölogical features of the region; the abundance of (harmless) alligators in the rivers; the absence of snakes from the forest plain of inundation, and their presence along the margin of the dry districts; the wasp-like severity of the bite of the ticks in the forests; the irritation produced by the abundance of parasitic insects on the pampas; the incredible abundance of bats in the houses, and their thirst for animal and human blood; the numerous species of monkeys; the large size of the cattle of the country south of the Bolivian (east and west) divide; the change in the voices of birds from harsh in the mountain regions to melodious on the plain; the anvil bird (tree toad?); the organ bird with its diatonic scale of eight ascending notes; the change of the plumage of paroquets from brilliant varied hues in the northern districts, to a general pale green in the southern; the abundance of struthious birds, and the incredible quantity of ant hills in the dry country.

After various questions asked by the members and visitors present, and answered by Dr. Heath, it was, on motion

Resolved, That the thanks of the Society be tendered to Dr. Heath for his very interesting and important communication.

Prof. Chase then made a short communication, placing data on the blackboard, to support a further enlargement of the range of applications of his photodynamic theory to natural phenomena; —and the meeting was adjourned.

Stated Meeting, November 18, 1881.

Present, 11 members.

President, Mr. FRALEY, in the Chair.

Mr. Sharpless accepted membership by letter, dated West Chester, October 29, 1881.

The Cincinnati Observatory acknowledged receipt of Proceedings No. 108.

The Chapultepec Observatory of Mexico requesting exchanges, was placed on the list of correspondents to receive the Proceedings regularly.

Donations for the Library were received from the Royal Society of Tasmania; the Geological Survey of India; Imperial Academy at St. Petersburg; German Geological Society and Society of Physics, Berlin; Natural Science Union, Bremen; Neues Lausitzisches Magazin, Görlitz; Royal Saxon Society, Fürstliche Jablonowskischen Gesellschaft, and Zoologischer Anzeiger, Leipsig; Royal Grand Ducal Institute, Luxembourg; Society of Physics, Geneva; Vaudoise Society, Lausanne; Swiss Society; Anthropological Society, Zoological Society, and Revue Politique, Paris; Revista Euskara, Pamplona; Nature, London; Royal Irish Academy, Dublin; Essex Institute, Salem; Boston Natural History Society; Museum of Comparative Zoology, Cambridge; Mr. Aug. R. Grote, Buffalo; Pharmaceutical Association, Historical Society, Franklin Institute, and the Editor of the American News, Philadelphia; Department of the Interior, and W. J. Hoffman, M. D., Washington; Astronomical Observatory of Chapultepec; Geographical and Statistical Society; Editors of

the Revista Mensual Climatologica, and the Revista Cientifica Mexicana, and the Ministerio de Fomento, Mexico.

An obituary notice of the late Wm. E. DuBois, was, by appointment, read by Mr. Robert Patterson.*

Dr. Brinton explained to the Society the substance of his paper on the Gods in the Kiché Myth, the Popol Vuh.

Mr. Lesley read Dr. Newberry's paper on the Origin of the Lake Basins, and then remarked on the relation of Dr. Newberry's claims to Prof. Spencer's discoveries and views.†

Mr. Lesley gave a short sketch of the history and progress of the excavations at Assos during the last few months, under the auspices of the Boston Archæological Society, as he obtained it in conversations with Prof. W. R. Ware of Columbia College.

The minutes of the last meeting of the Board of Officers and members in Council were read, and the consideration of the resolution therein was postponed for the next meeting.

Certain valuable manuscripts were ordered, on motion of Dr. Brinton, to be placed by the Library Committee in the custody of the Fidelity for safe keeping.

Pending nomination No. 935, and new nominations Nos. 946 to 950 were read, and the meeting was adjourned.

Photodynamic Notes, IV. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, November 4, 1881.)

91. *Photodynamic Determination of Sun's Mass and Distance.*

In Notes 5 and 28, I estimated Sun's mass both from projectile and from simple oscillatory considerations. In the former note I deduced the distance from an assumed solar density, instead of taking the ratio of variability $d^3 \propto mt^2$. My conviction of the importance of Fourier's theorem has been strengthened by further study, and I accordingly give, in the present note, the coördinate photodynamic elements which may be simply deduced from it.

If we regard the luminiferous æther as a nebulous elastic atmosphere, and the solar system as a partially condensed nebula, the nebula is not homogeneous. It contains, in addition to various subordinate and com-

* This paper will be printed in Vol. xx, No. 111.

† Dr. Newberry's paper will be printed in Vol. xx, No. 111.

paratively unimportant nuclei, two principal and controlling nuclei of nearly equal density, viz.: Sun, at the principal centre of nucleation, and Jupiter at the mean nebular centre between Uranus at apojove, and Neptune at perijove.

The actions and reactions between these controlling nuclei have produced an intermediate maximum condensation in the belt of dense planets, with a principal mass, Earth, near the centre of the belt. The solar radiations are propagated with the velocity of light, v_λ. If we designate Earth's mass by m_3, the actions and reactions of photodynamic *vis viva* at the centre of density, $m_3 v_\lambda^2$, produce gravitating tendencies towards the linear centre of gravity ($\frac{1}{2}$), the centre of linear oscillation ($\frac{2}{3}$), and the centre of conical oscillation ($\frac{3}{4}$), which vary as the fourth power* of the tendencies to orbital velocity. These tendencies are all satisfied by a reacting mass, $m_3 =$ $(\frac{1}{2} \times \frac{2}{3} \times \frac{3}{4})^4 m_0 =$ [illegible] of Sun's mass. The photodynamic character of the oscillatory *vis viva* at the centre of condensation is shown by the following proportions:

$$(1) \qquad m_0 v_0^2 : m_3 v_\lambda^2 :: m_5 v_\lambda^2 : m_3 v_0^2$$

$$(2) \qquad v_\lambda : v_0 :: v_0 : v_n$$

$$(3) \qquad v_n^4 : v_3^4 :: p_3 : p_0$$

In these proportions m_0 is taken as the unit of mass; Jupiter's mass, $m_5 = \frac{1}{1047.879}$; $v_n =$ orbital velocity at centre of condensation; v_0 is a mean proportional between v_λ and v_n; $p_0 =$ ratio of mean photodynamic projection of Sun's centre from the centre of gravity of Sun and Jupiter, Sun's semi-diameter being the unit; $p_3 =$ mean photodynamic projection of the centre of condensation from Earth's semi axis major as a unit; these projections, like the gravitating tendencies, vary as the fourth power of orbital velocity.

If we take $t_\lambda = 497.827$ seconds, and $g = 32.088$ feet, the above proportions give

$v_\lambda =$	186381.4	miles =	299943.5	kilometres.
$v_0 =$	1841.017	" =	2962.75	"
$v_n =$	18.185	" =	29.265	"
$v_3 =$	18.4735	" =	29.729	"
$p_3 =$	1.015866.			
$p_0 =$	1.06499.†			
$\rho_3 =$	92785700	miles =	149320000	kilometers.
$r_0 =$	432574.9	" =	696143.3	"

$n = \rho_3 \div r_0 = 214.496.$

Sun's parallax $= 8''.8004.$

*$g \propto \frac{1}{d^2}$; $v = \sqrt{gr} \propto \sqrt{\frac{1}{d}}$; $\therefore g \propto v^4$.

† Stockwell's estimate (*Smithsonian Contrib.*, 232, p. 38), is [illegible] = 1.06167 r_0.

92. *Latent Heat of Steam.*

The maintenance of the primitive velocity of undulation is exemplified in the relation between the projectile energy of evaporation and the energy of solar rotation. The equatorial velocity of solar rotation is $\frac{\pi g_o r_o}{v_\lambda}$. The mean rotating velocity of the locus of the centre of gravity of Sun and Jupiter is, therefore, $v_p = \frac{p_o \pi g_o r_o}{v_\lambda}$. The centre of gravity itself does not rotate, but its action produces æthereal photodynamic undulations, which are propagated with the velocity v_p, *which is equivalent to the projectile velocity of evaporation*, v_s;

$$v_p = v_s.$$

This equation is so important that it may be well to give the calculation in full :

$m_o \div m_3 = (2 \times 3 \times 4)^4 = 331776$	5.5208450
1 year $= 31558149$ seconds $= t_1$	7.4991115
$t_3 = 2\pi \sqrt{\frac{r_3 = 3962.8 \text{ miles}}{g_3 = 32.088 \text{ feet}}} \doteq 5073.6$ seconds	3.7053158
$\nu = \rho_3 \div r_3 = \left(\frac{t_1^2\, m_o}{t_3^2\, m_3}\right)^{\frac{1}{3}} \doteq 23414.2$	4.3694788
$\rho_3 = \nu\, r_3 \doteq 92{,}785{,}700$ miles	7.9674810
$v_o = v_\lambda = \rho_3 \div 497.827 \doteq 186381.4$ miles	5.2704025
$p_3 = 1.015866$	.0068364
$p_o = p_3^4 = 1.06499$	.0273455
$\rho_5 = (p_o m_o \div m_5)\, r_o = 1.06499 \times 1047.879\, r_o \doteq 1115.98\, r_o$	3.0476566
$n = \rho_5 \div 5.202798\, r_o \doteq 214.496$	2.3314197
$r_o = \rho_3 \div n \doteq 432574.9$ miles	5.6360613
$\sqrt{g_o r_o} = 2\pi n^{\frac{3}{2}}\, r_o \div t_1 \doteq 270.557$ miles	2.4322593
$\therefore v_p \doteq v_s \doteq 1.31405$ miles	.1186113

From this equation the latent heat of steam, θ, can be readily found, by the equations

$$v_s = \sqrt{2gh}$$

$$\theta = \frac{h}{1389.6}$$

Solving these equations we get

$h \doteq 142.064$ miles $\doteq 750098$ feet	5.8751178
$\theta \doteq 539^\circ.794$ C	2.7322280

The following values of θ have been deduced experimentally :

Favre and Silbermann	535°.77
Andrews	535°.90
Regnault	536°.67
Tyndall	537°.20
Despretz	540°.00
Dulong	543°.00

93. *Internal Energy of Ice.*

According to the kinetic theory of gases, the internal movements of the particles of steam are rectilinear, representing a total *vis viva* of projection, against the uniform resistance of gravity, of about $\frac{1}{2} \times 1389.6\, \theta$ feet $\doteq$ 189.42 miles. While the steam is condensed in the form of water or ice, the internal energies tend to maintain a spherical figure. The resultant oscillations (Note 23), can therefore be represented by a conical pendulum of $\frac{1}{4}$ the height of total projection, or $\frac{1}{8}$ of the projectile *vis viva* of evaporation. This gives, for the virtual fall from incipient ebullition to total congelation, $h_1 = \frac{1}{4} h \doteq 47.355$ miles $\doteq$ 250033 feet; and for the heat of sphericity $\theta_1 = \frac{1}{8}\theta \doteq 179°.931$ C. Deducting 100° for the expansion from the freezing to the boiling point, we have 79°.931 for the "latent heat" of ice, or the heat which is required to overcome its internal energy. The following values have been deduced experimentally:

Desains and De la Provostaye	79°.25
Black	79°.44
Person	80°.00
Hess	80°.34

94. *Photodynamic Moment of Inertia.*

Much of the difficulty which has been encountered in trying to reconcile the nebular hypothesis with actual planetary arrangements, has arisen from overlooking the difference between nucleal retardation and free orbital revolution. Herschel's doctrine of "subsidence" removes this difficulty, and an examination of the primitive planetary belt, before any of its successive divisions into asteroidal and intra-asteroidal belts, two-planet belts, and single-planet belts, shows the photodynamic influence in a very striking manner. The limit of photodynamic *nucleal* rotation is in the asteroidal belt; the photodynamic limit of "subsidence" rotation is at the solar modulus of light. I have often shown* that Saturn represents the photodynamic centre of inertial moment; in the division of inertia among the several belts, provision has been made for the change of linear into synchronous conical oscillations (4 : 1); for the change of synchronous into orbital oscillations ($t \propto l^{\frac{3}{2}}$); for the ratio of nebular radii to radii of subsidence-collision ($\frac{3}{2}$); and for the relative variability of centripetal and orbital tendencies, ($g \propto v_6^{4}$). Hence we find

$$4^{\frac{3}{2}} \times (\tfrac{3}{2})^4 \times M_0 : m_6 : : V_0 : v_6$$

Substituting the values of V_0 and v_6 (Note 92) we get

$$M_0 = 3502.2\, m_6.$$

Bessel's estimate was 3501.6.

95. *Photodynamic Centres of Gravity.*

An interesting approximation is shown by the ratio

$$3^3 \times 5 \times M_0 : m_5 : : V_0 : v_3.$$

* Note 12; *ante*, xviii, 431; *et al.*

The ratio of the foregoing note may be expressed as follows:

$$3^4 M_0 : 2\, m_s :: V_0 : v_3.$$

Combining these ratios we get

$$3\, m_5 = 10\, m_s.$$

The repetition of the pendulum-ratio, and the simplicity of the harmonic factors make these ratios so suggestive that they seem worthy of further study.

96. *Universal Energy of Light.*

It may be well to state the principal facts which are embodied in notes 90-95, in such a way as to show more clearly the simplicity of the relations of the several physical velocities to the velocity of solar radiation.

1. $$\frac{v_\lambda}{u_3} = \frac{h_0}{h_3} = \frac{M_0}{m_3} = \left(\frac{t_n}{t_e}\right)^2 \times \sqrt{\frac{\varphi_0}{\varphi_3}}$$

2. $$\frac{v_\lambda}{v_3} = 1\, \frac{M_0\, m_5}{m_3} = \frac{M_0\, t_e}{m_3\, t_n} \times \sqrt{\frac{\mu}{\chi}}$$

3. $$\frac{v_\lambda}{v_s} = \frac{3^4 M_0}{2\, m_s}$$

4. $$v_\lambda v_r = v_0^2 \times \frac{t_n}{t_e}$$

5. $v_s = v_p$ (Note 92)

6. $v_\lambda = g_0 t_0$.

In these equations, v_r = velocity of equatorial rotation which Sun would have if it were expanded to the locus of a particle which revolves with the circular-orbital velocity v_0; by the law of conservation of areas v_r varies inversely as radius, while v_0 varies inversely as the square root of radius; v_3 = Earth's orbital velocity.

If we assume $M_0 = 328470 m_3$, we find $h_0 = 92476500$ miles; $v_\lambda = 185760$ miles; $v_3 = 18.412$ miles; $u_3 = 2986$ ft.; $v_s = 6916.2$ ft. The following table shows the accordance between theoretical and observed values:

	Theoretical.	Observed.
1. Boiling point,	99.°98	100°
Combining heat of H_2O,	69319	67616. to 69584*
φ_0	140.65	140 lbs. per sq. in.
2. v_3	18.31	18.41
$\chi \div \mu$	107.38	106.67
3. Latent heat of steam,	536.°374	536.°385†

In these comparisons I have made no allowance for the photodynamic projections which have caused orbital eccentricities, as it may be pre-

* See Note 16.

† Mean of first four estimates in Note 92.

sumed that they have affected different elements in different ways and to different degrees. I still think that the true value of M_0 is about one per cent. greater, and the value of h_0 about $\frac{1}{3}$ of one per cent. greater than here given.

Weber and Kohlrausch demonstrated the importance of photic velocity in electromotive energy, by measuring quantity of electricity; Thomson and Maxwell, by measuring electromotive force; Ayrton and Perry, by measuring electrostatic capacity.

97. *Maximum Density of Water.*

If we let u_4 represent the potential velocity of water at its greatest density, we find that the greatest known velocity of æthereal wave-propagation : the greatest known gravitating velocity : : the corresponding circular-orbital velocity : the potential velocity of water at its greatest density.

$$v_\lambda : v_0 \sqrt{2} : : v_0 : u_4 \qquad (1)$$

Let θ = 100° C. — water-temperature of maximum density; ρ_3 = Earth's semi-axis major $= nr_0$; r_0 = Sun's semi-diameter. Then

$$v_\lambda = \rho_3 \div 497.827 \qquad (2)$$

$$v_0 = n^{\frac{1}{2}} \times 2\pi\rho_3 \div 1 \text{ year in seconds} \qquad (3)$$

$$u_4 = \sqrt{2gh} = \sqrt{2g\theta \times 1389.6 \div 5280} \qquad (4)$$

If we substitute (2), (3) and (4) in (1), and adopt the British Nautical Almanac estimate, $n = 214.45$, the most satisfactory experimental determinations of θ give the following results:

Authorities.	θ	u_4	ρ_3
C. Von Neumann	96°.32	.55508 miles.	92,746,800 miles.
Plücker and Geissler	96.20	.55473 "	92,689,100 "
G. Hagen	96.13	.55453 "	92,655,300 "
Joule and Playfair	96.055	.55432 "	92,619,200 "
F. Exner	96.055	.55432 "	92,619,200 "
Despretz	96.00	.55416 "	92,592,700 "
F. Rossetti	95.93	.55396 "	92,558,900 "
H. Kopp	95.92	.55393 "	92,554,100 "
Mean	96.076	.55438 "	92,629,300 "

Whatever value may be adopted for Sun's apparent semi-diameter and for θ, the corresponding value for Earth's semi-axis major may be readily found, since $\rho_3 \propto \sqrt{\frac{\theta}{n}}$.

98. *Electric Mass.*

Many of the foregoing relations seem to show that if the factor M. in electric dimensions, has any proper analogy to the mass-factor in ordinary energy, it should be referred to the particles, or the most minute ap-

preciable portions of luminiferous æther. Professor S. P. Thompson, in the Philosophical Magazine for July, 1881,* makes the following noteworthy suggestion:

"Matter has dimensions [M], Energy [ML^2T^{-2}], and Electricity $\left[M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-1}\right]$. The latter value is obtained from a consideration of the Law of Coulomb, that $Q \times Q \div L^2 = \text{force} = \left[ML\,T^{-2}\right]$; whence

$$Q = \left[(ML^3T^{-2})^{\frac{1}{2}}\right].$$

But the dimensions of self-attractive matter may be similarly considered by Newton's Law that $-M.M \div L^2 = \text{force} = [M\,L\,T^{-2}]$, whence

$$M = [-L^3\,T^{-2}].$$

And if this value be put in place of M in the dimensions of Q above, we get $Q = \left[\sqrt{-1}\,(L^3\,T^{-2})\right]$, a quantity whose dimensions differ only from those of M in being prefixed by the imaginary quantity $\sqrt{-1}$. This seems to indicate an important relation."

99. *Change of State.*

In the Philosophical Magazine for July, 1881, Professor J. H. Poynting discusses "Change of State; Solid-Liquid." He shows that it follows from his "mode of regarding the subject, that, if in any way the ice can be subjected to pressure while the water in contact with it is not so subjected, then the lowering of the melting point per atmosphere is about $11\frac{1}{2}$ times as great as when both are compressed" (p. 34). In Herschel's hypothesis of nebular "subsidence" a similar action is implied, the nebulous or ætherreal atmosphere corresponding to the uncompressed water, and the subsiding particles, under the gravitating pressure, corresponding to the compressed ice. In a former study of potential energy (Proc. Soc. Phil. Amer., xvii, 98), I showed that, under such circumstances, "the increase of radial velocity would be sufficient to produce orbital velocity in the periphery of a stationary nebula, when $\sqrt{n} = \sqrt{2}\,(\sqrt{n}-1)$, and $n = \frac{2}{3-2\sqrt{2}} = 11.656854$." The important bearing of this relation upon planetary positions was also shown at the same time.

100. *Earth's Photodynamic Condensation.*

Let t_λ = time in which solar superficial gravitation would communicate the velocity of light, or time of solar half-rotation; t_5 = Jupiter's orbital time; r_3 = Earth's semi-diameter; $r_4 = 338.2183\,r_3$ = Earth's synchronous radius, or distance at which a particle would revolve about Earth, synchronously with Earth's revolution about Sun,

Then $$r_4 : r_3 :: t_5 : t_\lambda.$$

This gives 12.81 days for t_λ, or 25.62 days for Sun's rotation, which is $\frac{1}{2}$

*Foot-note page 17.

of one per cent. greater than Laplace's estimate and than the mean value which is indicated by other photodynamic considerations.

101. *Earth's Rigidity.*

Sir William Thomson concluded, from investigations of tidal action and equinoctial precession, that "the earth as a whole is much more rigid than any of the rocks that constitute its upper crust," and that the mean tidal effective rigidity must be greater than that of glass. The inconsistency of this hypothesis with the belief of the internal fluidity of the earth led many to question it. Gen. J. G. Barnard (Smithsonian Contributions, 240) applied the principles of the gyroscope to the explanation of precession, and endeavored to show that no increase in the rate of precession arises from fluidity. Thomson subsequently modified his views (Brit. Assoc. Rep., 1876) in accordance with his theory of vortex-atoms, by considerations based on the quasi-rigidity introduced into a liquid by vortex motion. The stress of the æthereal waves must have an important influence both upon the gyroscopic and upon the vortical tendencies, and the rapidity with which they are propagated may perhaps furnish the substitute for the inconceivable rigidity which seemed to be required in the first discussion of the problem.

102. *Sun's Internal Temperature.*

In Note 58, I gave two photodynamic estimates of solar temperature, the second being 3.07 per cent. greater than the first. The second estimate was based on the hypothesis that the whole mass of the Sun is either fluid or gaseous, so that every particle is continually yielding to tendencies toward Sun's centre, toward the centre of gravity of the solar system and toward the immediate centre of gravity. If the whole mass could be collected at Sun's centre, it would revolve about the centre of gravity of the solar system in less than three hours, but the rotation on the axis which partially compensates for the tendency to revolution, requires about 25.5 days. The orbital motion of the Sun about the centre of its stellar system furnishes a slight additional compensation, but the photodynamic stress seems to be mainly represented by radial oscillations which are synchronous with the orbital revolution which Sun's centre would have if it were free. The potential velocity which represents such radial oscillations is that which would be acquired by vertical fall through half of the diameter, or perihelion parabolic velocity.

103. *Earth's Internal Temperature.*

The small mass of Earth interposes little opposition to orbital tendencies, and its greatest velocity of axial rotation is only about $\frac{1}{54}$ as great as its solar orbital velocity. If Earth's whole mass was homogeneous, gravity within its mass would vary as distance from centre, and the *mean* tendency to orbital velocity, in reaction against the stress of æthereal undulations would be represented by a virtual fall through $\frac{1}{4}$ of radius, or 990.7 [illegible]

This represents a thermal energy of 990.7 × 5280 ÷ 1389.6 = 3764.82 calories, which would be communicated by a temperature of 3764°.82 C., or 6775°.78 F. The temperature of melting rock is estimated by Sir William Thomson (Thomson and Tait's Natural Philosophy, i, App. D., p. 716) at 7000° F. Notwithstanding the crudeness of this approximation, it shows that the temperature which represents orbital reactions against æthereal stress is of the same order of magnitude as that of melted rock, thus corroborating other evidence of the probable fluid condition of the greater portion of our globe.

104. *Barometric Strain.*

The evidence which I presented in 1863 (Proc. Soc. Phil. Amer., ix, 283-8), of cyclical atmospheric strains resulting from the combined stresses of pressure, inertia and elasticity, presents an interesting problem for mathematical analysis. I confined myself to an investigation of mere numerical results; in generalizing and extending them, the following FACTS seem most important:

1. The atmospheric daily variation of solar or terrestrial centripetal inertia is comparatively insignificant.

2. The variation of tangential orbital motion, between noon and midnight, is about $\frac{1}{37}$ of the mean motion; the consequent variation in the moment of inertia is about $\frac{1}{18}$ of the mean moment.

3. The orbital moment of inertia is more than 4000 times as great as the equatorial rotary moment.

4. The combined influences of elasticity and orbital moment of inertia tend to drive the atmospheric particles away from the Earth during the first and third quarters of the day, and towards the Earth during the second and fourth quarters.

5. The sum of the instantaneously varying tendencies reaches a maximum in the middle of each quarter.

6. The ratio of the mean equatorial daily variation of the barometer (above or below its mean altitude), to its mean altitude, corresponds very closely to the ratio of equatorial daily rotation (24,895 miles) to the sum of Earth's synodic daily gravitating reactions against Sun's gravitating action ($86400^2 \times 16.044 \div 5280 = 22683300$ miles).

7. The time of maximum disturbance in each quarter of the day, is delayed about an hour after the middle of the quarter at tropical stations.

8. The magnitude of the disturbances in the morning and afternoon is increased by the atmospheric expansion which is due to solar heat.

9. The magnitude of the disturbances during the night is diminished in such proportion as to maintain the *average* quarter-daily change, which is required by the actions and reactions of elasticity and inertia.

10. The tendency to description of equal areas in equal times, leads approximately to the proportion, especially within the tropics,

$$e^2 : e_1^2 :: r : r_1.$$

In this proportion e represents the daily barometric range; e_1, the annual

range; r, the virtual radius of daily inertia, $86400^2\, g \div 2$; r_1, the radius of annual inertia, Earth's semi-axis major.

105. *The St. Helena Test.*

The most extensive and satisfactory intertropical observations that appear to have been published, are those of Gen. Sabine, at St. Helena, in latitude 15°57′S. Ganot's formula, $g = 32.174\,(1 - .00256 \cos. 2\,\varphi)$, gives $g = 32.104$, and $r = 86400^2 \times 16.052 \div 5280 = 22694600$ miles. The mean of five years' observation gives $e = .067$ in.; $e_1 = .135$ in.; $r_1 = \frac{e_1^2\, r}{e^2} = 92138400$ miles. This differs by less than ⅜ of one per cent. from the greatest value that seems likely to result from the final discussion of the observations of the last transit of Venus, and by less than ⅛ of one per cent. from the result that has been indicated by some of the recent English discussions. The simplicity of this relation, in the case of our planet, is perhaps due partly to Earth's position at the centre of condensation in the solar system.

106. *Gaseous Diffusion.*

Doebereiner, in his researches on spongy platinum, accidentally used a jar which had a slight crack or fissure. He was surprised to find that the water of the pneumatic trough rose into the jar two and two-third inches in twenty-four hours, although there had been no sensible change in the height of the barometer or the heat of the room. This observation led Graham (*Chemical and Physical Researches*, p. 44; *Phil. Mag.*, and *Pogg. Ann.*, 1833), to the experiment from which he deduced his law of gaseous diffusion: "The diffusion or spontaneous intermixture of two gases in contact is effected by an interchange in position of indefinitely minute volumes of the gases, which volumes are not necessarily of equal magnitude, being, in the case of each gas, inversely proportional to the square root of the density of that gas." He subsequently (*Researches*, p. 88; *Phil. Trans.* 1846, 1849), showed that this was a result of diffusive velocities varying "inversely. as the square root of their densities," referring also to "the theoretical law of the passage of gases into a vacuum, according to the well-known theorem that the molecules of a gas rush into a vacuum with the velocity they would acquire by falling from the summit of an atmosphere of the gas of the same density throughout; while the height of such an atmosphere, composed of different gases, is inversely as their specific gravities. This is a particular case of the general law of the movement of fluids, well established by observation for liquids, and extended by analogy to gases." These views involve all the consequences of equality of *vis viva*, in chemical as well as physical actions and reactions, and they indicate the direction in which we may still look hopefully for an extension of our knowledge of chemical physics.

107. *Kinetic and Static Energies.*

Motions, or tendencies to motion, v_1, in elliptical orbits, vary in the inverse ratio of the distance from the centre of gravity. The acceleration of a particle by any given mass, g, varies inversely as the square of the distance. Orbital velocity of a particle, v_0, varies inversely as the square root of the distance. Velocity of gaseous diffusion, v_2, varies inversely as the square root of the density, or inversely as orbital time, or inversely as the $\frac{3}{2}$ power of the mean distance.

$$g \propto \frac{1}{r^2} \propto v_0^4$$

$$v_2 \propto \left(\frac{1}{r}\right)^{\frac{3}{2}} \propto v_0^3$$

$$v_1 \propto \frac{1}{r} \propto v_0^2$$

$$v_0 \propto \left(\frac{1}{r}\right)^{\frac{1}{2}} \propto v_0$$

These several relations all seem likely to be involved in different problems of chemical physics.

108. *Critical Temperatures.*

Notes 58, 93–7, 102–3, indicate a variety of thermodynamic relations to mass, which may be special instances of a large class. Circular, parabolic, and dissociative velocities introduce the factors $\sqrt{2}$ and π, and temperatures vary as the square roots of their representative velocities. Hence may arise an indefinite number of critical temperatures. The two which immediately follow Earth's theoretical internal temperature, Note 103, are 9582°.4 and 12009°.8 F. These temperatures may, perhaps, have important bearings upon questions of specific heat, and specific and atomic *vis viva*.

109. *Harmonic Spectrum of Arsenic* [*and Thallium*].

The American Journal of Science, for September, 1881, publishes Huntington's Arsenic Spectrum, printing in heavy type "the bands which are most brilliant and give character to the spectrum. The other lines are less constant and less distinct, and in some instances may be due to accidental causes." "Upon examining the spectrum it appeared evident that thallium must be present in the arsenic in large quantities." The relations of the observed lines to lines which are in harmonic progression are shown in the following table.

Wave-Length.		Divisors.		
Harmonic.	Observed.	Harmonic.		Observed.
6023	6023			
6012	6013	236x =	1.0018	1.0017
5815	5813	244x	1.0358	1.0361
5653	5653	251x	1.0655	1.0653
5564	5563	255x	1.0825	1.0827
5499	5498	258x	1.0952	1.0955
5334	5340Tl	266x	1.1292	1.1279
5104	5103	278x	1.1801	1.1803
4622	4623	307x	1.3032	1.3028
4592	4593	309x	1.3117	1.3113

The thallium line, 5340, is the only one which differs enough from the harmonic length to throw doubt on its subjection to harmonic influence. If this line were omitted altogether in the calculation, the only change would be in the fourth harmonic divisor, which would be 1.0824 instead of 1.0825. The harmonic wave-lengths would all remain the same as above given.

110. *Mechanical Analogies.*

The researches of Challis and Norton have shown how extensively the various operations of energy may be represented and anticipated by applying the laws of fluid motion. My own kinetic investigations have been greatly helped by my apparatus,* for imitating the "lines of force" which are represented by atmospheric, thermal and electric currents. The telephone, phonograph and photophone furnish practical illustrations of the "mechanical polarization" for which my apparatus was devised. M. C. A. Bjerknes has lately sent a communication to the French Academy "*sur l'imitation, par la voie hydrodynamique, des actions électriques et magnétiques.*" As the indications of unity of force increase, there will be an increased call for the study of such analogies with the help of mechanical contrivances.

111. *Subsident and Parametral Nodes.*

If we take Sun's semi-diameter, Laplace's limit and Earth's nascent locus† as the elements of the stellar-solar paraboloid, we find

$$\eta^2 = 2\,p\,\xi = .9958334$$
$$\xi = .1666667$$
$$2\,p = 5.950342$$

The product of the parameter by any paraboloidal abscissa represents the corresponding ordinal *vis viva*, and the laws of harmonic undulation in elastic media lead us to look for nodes in accordance with the living force. We find numerous evidences of such accordance in the primitive cometoid nebula, if we suppose the nucleal tendencies in the axis of abscissas to be

* For description see Proc. Amer. Phil. Soc., x, 151–66.

† Note 46, *ante*, xix, 446.

arranged in the following order; Neptune (N), Jupiter (J), Mars (M), Sun (S), Mercury (Me), Venus (V), Earth (E), Saturn (Sa) Uranus (U). Let subscript 1, 2, 3, 4, 5 designate, respectively, secular perihelion, mean perihelion, mean, mean aphelion, secular aphelion. Then

1. Subsidence from N_3 would produce a rupturing node at U_4.* Stockwell's values are, $N_3 = 30.034$, $U_4 = 20.044$, the rupturing locus being $\frac{2}{3}$ of $30.034 = 20.023$. Newcomb's estimate of N_3 is 30.070, which would give 20.047 for the rupturing locus.

2. Midway between these primitive nodes comes the primitive nebular centre, J_2. Three of Jupiter's cardinal loci are thus approximately indicated, viz.:

$$(N_3 - U_4) + 2 = 4.995 \; ; \; J_2 = 4.978$$
$$(N_5 - U_4) + 2 = 5.213 \; ; \; J_3 = 5.203$$
$$(N_5 - U_3) + 2 = 5.425 \; ; \; J_4 = 5.427.$$

3. The rupturing locus of the early nebular centre, J_1, and the locus of incipient subsidence at the centre of the belt of greatest condensation, E_5, present the most significant evidence of parametral influence.

$$J_1 + E_5 = 5.954 \; ; \; 2p\,E_3 = 5.950$$

4. Other important loci in the dense belt show a like influence.

$$J_3 + V_4 = 5.952$$
$$J_5 + Me_4 = 5.975$$

5. The influence of the parameter on other fundamental abscissas is equally evident.

$$2p\,Me_1 = 1.770 \; ; \; M_5 = 1.786$$
$$2p\,M_3 = 9.066 \; ; \; Sa_2 = 9.078$$
$$2p\,M_5 = 10.338 \; ; \; Sa_5 = 10.343$$
$$2p\,J_2 = 29.623 \; ; \; N_1 = 29.598$$
$$2p\,Sa_4 = 59.504 \; ; \; 2N_2 = 59.465$$

6. Simple ordinal influence is shown in the relations of Laplace's limit (L) to the centre of condensation, and of the three inner to the three outer planets, if we take Sun's semi-diameter (r_0) as the unit of measurement.

$$\sqrt{2p\,E_4 \div r_0} = 86.822 \; ; \; L = 86.866r_0$$
$$\sqrt{2p\,J_4 \div r_0} = 83.288 \; ; \; Me_3 = 83.048r_0$$
$$\sqrt{2p\,U_3 \div r_0} = 156.491 \; ; \; V_3 = 155.184r_0$$
$$\sqrt{2p\,N_5 \div r_0} = 197.228 \; ; \; E_1 = 200.008r_0$$

7. A similar influence is shown with E_3 as the fundamental abscissa.

$$\sqrt{2p}\,E_3 = 2.439 \; ; \; E_4 + M_2 = 2.437$$
$$2\sqrt{2p}\,E_3 = 4.879 \; ; \; J_1 = 4.886$$

8. Some of the relative nodes show simple multiples of the parameter.

$$4p = 11.901 \; ; \; N_1 - U_1 = 11.910 \; ; \; U_5 - Sa_1 = 11.945$$
$$6p = 17.851 \; ; \; U_1 = 17.688$$
$$10p = 29.750 \; ; \; N_2 = 29.732$$

* Ibid, xvii, 100.

112. *Motion of the Solar System.*

If the interstellar paraboloid (Note 46) were at rest, we should have $\eta = 2\xi$; it is, however, equivalent to 5.975ξ. I can think of no other reason for this increase than the absolute motion of the system in space. If the space traversed in a quarter of a solar rotation (6.377 days) is similarly increased we have

$$\xi : \eta\zeta :: r_0 : y$$

$$\text{or } \tfrac{1}{4} : 1.00877 :: r_0 : 6.05264 r_0$$

This would give, for the space traversed in a year, $\frac{365.256}{6.377} \times 6.05264 r_0$. Dividing by 214.45, we obtain 1.6166 times Earth's semi-axis major. Herschel's estimate of the annual motion* is 1.623 semi-axes.

113. *Relation between Jupiter's Mass and Distance.*

The original tendency to relative stability in the positions of the two principal masses of our system, on account of the magnitude of Sun and the nebular centrality of Jupiter, appears to have made Sun's surface the rupturing locus (secular perihelion), of the centre of gravity of the two bodies. Stockwell gives, for Jupiter's maximum eccentricity, .0608274; secular perihelion is, therefore, .9391796 of the semi-axis major. If we accept Bessel's mass, we find $1047.879 \div .9391796 = 1115.75 r_0$. Dividing by 5.202798, we find, for Earth's semi-axis major, $214.45 r_0$, which is the value adopted in the British Nautical Almanac.

114. *The Central Sun.*

The true culminating abscissa of the stellar-solar paraboloid (Note 46), is $\Lambda_{36} = LM \div r_0$. There is a very large *possible* uncertainty in the distance of *α Centauri*, and even if we take the most recent and careful estimates we may set down the probable error as at least $\pm .04$. Moreover, as the theoretical variability of the abscissas is principally due to variability of æthereal density, Λ_{36} may represent any point in the orbit of *α Centauri* about the centre of its stellar system. The mean R. A. of *α Centauri* is about 217°53′ and its declination 60°21′8; the opposite pole of the paraboloid, or the theoretical direction of the "Central Sun," if our Sun has been projected from *α Centauri*, should therefore be in the constellation Cassiopeia. The direction of Sun's apparent motion among the fixed stars has been variously estimated between R. A. 252°53′ and 261°22′, and between N. Dec. 38°37′, and 14°26′. Struve's result, from an elaborate discussion of the proper motions of 392 stars, was R. A. 261°22′, Dec. 27°36′, for A. D. 1790. This position is 4°31′ north of the great circle which is at right angles with the axis of the Centaurean paraboloid.

* Outlines of Astronomy, Sect. 858.

115. *The Milky Way and Mädler's Hypothesis.*

Sir John Herschel* objects to Mädler's assignment of "the local centre in space, round which the sun and stars revolve" to the group of the Pleiades, "lying as it does no less than 26° out of the plane of the galactic circle, out of which it is almost inconceivable that any *general* circulation can take place." No such objection can be urged against the radius-vector of the Centaurean paraboloid, for the Milky Way divides at *α Centauri*,* and it traverses Cassiopeia, "its brightest part passing about two degrees to the north of the star *δ* of that constellation."*

116. *Daily Variations of the Magnetic Needle.*

Sabine's discussions of the magnetic observations at various stations have shown :

1. That the diurnal variation of declination which is due to the Moon's action consists of four equal or nearly equal portions, in which the magnet is attracted alternately to the east and to the west of its mean position.

2. That there is a striking correspondence between the lunar-daily varitions of horizontal force and of declination.

3. That in the normal variations of vertical force, the lunar day is also divided into four alternating periods of nearly equal duration, in two of which the force is increased and in the other two it is diminished by the lunar influence.

4. That the lunar-daily variations of inclination and of total force also constitute double progressions, having two maxima and two minima, with alternate periods of increase and decrease, each period being of about six hours' duration.

5. That the solar-daily variations normally constitute only single progressions, of about twelve hours each, from maximum to minimum and from minimum to maximum.

6. That there are, however, "nocturnal episodes" of "retrogressive motion" at some stations, with tendencies to a triple instead of double division of the solar day.

I have shown, by experiment :

7. That any elongated body, when exposed to the action of parallel rectilinear undulations, tends to place itself in the line of those undulations.

8. That this tendency may be increased by giving the elongated body a slight specific energy of direction. For example : if the gimbals of a binnacle compass are so held as to allow motion only in one direction, and the box is made to swing on its free axis like a pendulum, the needle will tend towards the line of oscillation.

The single progression of the solar disturbances (5) and the double progression of the lunar disturbances (1—4) indicate a difference in the character of the chief disturbing influences of the two bodies. It is difficult to

* Op. cit. Sect., 861, 789, 787.

account for such difference by any theory of magnetic induction.* It is evident, however, that Sun's thermal disturbance of Earth's æthereal currents is greater than Moon's, while Moon's tidal disturbance of the same currents is greater than Sun's.

117. *Magnetic Variations at St. Helena.*

St. Helena, on account of its insular position, its proximity to the magnetic equator, its large horizontal force and the large proportion of total force which is represented by the horizontal force, is free from many of the local complications which often mask the normal action of the Sun and Moon. Moreover, the comparatively long period of systematic observations, the extension of the observations to the lunar action on the barometer as well as on the magnetic needle, the uniformity of the indications in different years and in different semesters, and the symmetry which is traceable between the lunar atmospheric and magnetic disturbances, are additional reasons for regarding it as a typical station for the study of gravitating influence on æthereal waves.

118. *Comparative Table.*

The difference between the solar and lunar disturbances is shown in the following synoptical table. The magnetic data are taken from the second volume of the St. Helena Observations, pp. xlii-xliv and lviii-lxii; the barometric, from the first volume, pp. 84, 99. The barometric *ratios* are given, in order to make the table homogeneous and facilitate comparison. They were obtained by dividing the hourly deviations from the mean by the mean height of the barometer (28.278 in.).

SOLAR DISTURBANCES.

h.	Bar.	V. F.	H. F.	T. F.
☉	.00	.000	.00	.000
0	+0566	—022	+1099	+95
1	—0035	+229	+0911	+82
2	—0530	+446	+0623	+60
3	—0954	+593	+0368	+40
4	—1061	+638	+0133	+20
5	—0920	+608	—0080	+01
6	—0636	+611	—0270	—15
7	—0212	+545	—0394	—26
8	+0247	+300	—0465	—36
9	+0636	+219	—0511	—41
10	+0848	+074	—0530	—45
11	+0742	—011	—0522	—45
12	+0354	—100	—0481	—43
13	—0106	—165	—0449	—41

*See paper by Dr. Lloyd, Proc. R. Irish Acad., 1858, and C. Chambers, Phil. Trans., 1863.

SOLAR DISTURBANCES.

h.	Bar.	V. F.	H. F.	T. F.
14	—0566	—224	—0405	—38
15	—0884	—280	—0376	—36
16	—0919	—345	—0352	—35
17	—0742	—398	—0329	—34
18	—0247	—465	—0298	—32
19	+0318	—518	—0154	—20
20	+0813	—582	+0130	+03
21	+1202	—491	+0470	+34
22	+1308	—425	+0803	+63
23	+1061	—214	+1019	+85

LUNAR DISTURBANCES.

h.	Bar.	V. F.	H. F.	T. F.
	.000	.0000	.0000	.0000
0	+619	—05	+06	+05
1	+523	+27	—03	—01
2	+300	+31	—11	—05
3	—035	+44	—14	—06
4	—318	+72	—20	—07
5	—477	+41	—14	—06
6	—749	+50	—07	+01
7	—619	+28	—04	+01
8	—290	—12	00	—02
9	+007	—11	+22	+18
10	+205	—17	+32	+25
11	+488	—37	+31	+22
12	+566	—03	+19	+16
13	+417	+05	+17	+15
14	+194	+19	+13	+14
15	—255	+48	—09	—01
16	—417	+51	—11	—02
17	—530	+29	—08	—03
18	—644	+13	—09	—06
19	—513	—11	—04	—05
20	—290	—53	+03	—05
21	—265	—50	+06	—02
22	+407	—54	+13	+04
23	+548	—67	+09	—01

119. *Magnetic Correlations.*

In studying the above table for a proper interpretation of its indications, we can follow no better clew than the known correlations of electricity and magnetism, which may be classed under the following heads :

a. Friction.—Thermal and tidal currents, combined with the resistance of the Earth's surface, must produce atmospheric friction.

β. Chemical Action.—The evidences of incessant dissociation and re-association in the solar photosphere, are so conclusive, that chemical action may be very properly regarded as an important source of specific solar magnetism.

γ. Light.—The numerical equivalences between various forms of luminous, gravitating, and electro-magnetic action, are so striking as to justify Maxwell in the assertion that "the properties of the electro-magnetic medium are identical with those of the luminiferous medium."*

δ. Heat.—Edlund has shown that many of the phenomena of heat and electricity may be explained by the hypothesis of two forms of motion in the same elastic æthereal medium.

ε. Rotation.—Arago, Babbage, Herschel, Barlow, Christie, Chase, and Perry and Ayrton, have shown that simple rotation produces magnetical disturbances which are governed by fixed laws.

ζ. Gravitation.—In addition to the relation which I have shown to exist between solar rotation and luminous velocity, it is evident that electricity must be modified by pressure and by such changes in the relative distances of electrified particles as are produced by disturbances of gravitating equilibrium.

η. Currents.—A comparison of oceanic currents with the cotidal lines, the lines of isabnormal temperature and the magnetic lines of equal declination, shows such points of resemblance as to make it probable that they are all due to the action of the same forces upon different media, or under different circumstances. Challis has found that if all the ordinary central forces are due to transformed æthereal vibrations, "the actions of such forces on atoms are in every instance attributable to *æthereal currents*, whether the atoms be *immediately* acted upon by steady motions of the æther or by æthereal vibrations." †

120. *Comparison of Solar Daily Magnetic and Meteorological Means.*

The solar-daily maximum of vertical force at St. Helena is coincident with the daily barometric minimum, as well as with the minimum of gaseous pressure and of mean pressure of the wind. The daily minimum of vertical force (20 h) is approximately coincident with the daily maximum of the barometer (22 h), of gaseous pressure (21 h), and of wind pressure (22–23 h). The most rapid increase of vertical force is between 22 h and 8 h, when the barometer is falling and the gaseous pressure diminishing: the most rapid diminution is between 7 h and 10 h, when the barometer is rising and the gaseous pressure increasing. The range of total force between noon and midnight (.00095 + .00043 = .00138), is of the same order of magnitude as the daily range of solar disturbances of weight or pressure $\left(\frac{m}{d^2{}_3}\right.$ = .000615, which is added at midnight and subtracted at

* *Electricity and Magnetism*, ii, 383, sqq.
† *Phil. Mag.*, Sept. 1872; Sept. 1876; June, 1878.

noon, making the total range .00123). The arithmetical mean of any cumulative disturbances which are occasioned by the accelerations and retardations of alternate half-daily fall towards and rise from the Sun, should occur at 12h ∓ $\frac{1}{3}$ from midnight, or at 8h. 29m. A.M. and 3h. 31m. P.M. These hours correspond very nearly with those of mean disturbance, both in the horizontal and in the total force:

	Noon.	12 P.M.	Mean.	Time of Mean.
H. F.	+.001099	—.000481	+.000309	8h. 31m. A.M.; 3h. 16m. P.M.
T. F.	+.00095	—.00043	+.00026	8h. 45m. A.M.; 3h. 42m. P.M.

The greatest observed deviation from the theoretical times is 16m, in the morning mean of total force; the least, 2m., in the morning mean of horizontal force. The mean deviation of horizontal force is 8.5m.; of total force, 2.5m.

121. *Lunar Daily Comparison.*

The lunar disturbances, both of the barometric and of the magnetic means, are of a higher order than can be accounted for by mere disturbances of weight or pressure, or by any other known activity of our satellite except the accumulation of energy in currents (η). We have no reason to think that the moon exerts any specific chemical (β), luminous (γ), or thermal (δ) influence of her own, but her tidal disturbances of the elastic or *quasi*-elastic currents of the rotating earth (ε, ζ, η) are very important.

Schiapparelli, Loomis and Chase have shown that long-continued observations, at various stations, demonstrate the existence of an evident lunar influence on the precipitation of rain, and, consequently, on the electrical condition of the atmosphere. Each station has an "establishment" of its own, which can be determined, where the meteorological conditions are most uniform, by observations extending over a period of three or four years. This influence, which is undoubtedly due to tidal disturbances of atmospheric currents, is further shown in the lunar modifications of the direction and velocity of the wind, which have been pointed out by M. Bouquet de la Grye.*

Both in the lunar and in the solar tables the critical periods of horizontal and total force are nearly synchronous. In the lunar variations the vertical force increases as the horizontal force diminishes, and *vice-versâ*. Each of the lunar magnetic tides is of the same general character as the oceanic and atmospheric tides. The lunar horizontal force and total force are greatest and the vertical force is least when the barometric currents are moving most rapidly away from the Earth's centre; the horizontal and total force are least and the vertical force is greatest when the currents are moving most rapidly towards the centre.

The range of lunar disturbances of vertical force (from + .000072 to

* *Comptes Rendus*, lxxxviii, 345-8.

— .000067 = .000139) is almost identical with the range of lunar barometric disturbances (from — .000075 to + .000062 = .000137).

The culminations of the lunar disturbances, both of the vertical and of the horizontal force, correspond approximately with the mean sum of the accelerations and retardations of lunar tidal action by terrestrial rotation ($6h \div \sqrt{2} = 4h\ 14.6m$ after 0h, 6h, 12h, 18h.)

Vertical Force.		Horizontal Force.	
1st Max.	0h + 3h 57m	1st Min.	0h. + 4h 1.3m
1st Min.	6h + 4h 51.5m	1st Max.	6h. + 4h 24.4m
2d Max.	12h + 3h 36.1m	2d Min.	12h. + 3h 44m
2d Min.	18h + 4h 39.8m	2d Max.	18h. + 4h 9.2m
Mean	4h 16.1m	Mean	4h 4.7m

122. *Conclusions.*

Although the barometric observations furnish the most ready data for quantitative measurements and comparisons, the combined action of terrestrial rotation with lunar tidal and terrestrial equilibrating gravitation is not confined to the air. Every particle of the globe is continually subject to cyclical variations of stress and strain. In the first and third quadrants the lunar action is opposed, while in the second and fourth it is aided, by terrestrial rotation, so that the resultant of all the subterranean magnetic influences must be subject to lunar disturbances of the same character as those which modify the barometric and electric currents in the atmosphere.

We may, therefore, conclude that the solar disturbance of the terrestrial magnetic currents is chiefly and primarily due to its thermal activity ; the lunar, to gravitating currents which are modified by terrestrial rotation and orbital revolution.

123. "*Forced Oscillation.*"

In discussing the synchronism of the motion of the moon's nodes with terrestrial nutation Herschel* introduces "the principle of forced oscillations, or of forced vibrations," by the following announcement:

"If one part of any system connected either by material ties, or by the mutual attractions of its members, be continually maintained by any cause, whether inherent in the constitution of the system or external to it, in a state of regular periodic motion, that motion will be propagated throughout the whole system, and will give rise, in every member of it and in every part of each member, to periodic movements executed in equal period with that to which they owe their origin, though not necessarily synchronous with them in their maxima and minima."

A demonstration of this theorem for the forced vibrations of systems connected by material ties of imperfect elasticity, is given in Herschel's Treatise on Sound.† Fourier's theorem, Herschel's theory of the consequences of

* *Op. cit.*, Sect. 650.

† Encyc. Metrop., Art. 323.

nebular subsidence, and the various forms of harmonic synchronism are all dependent upon the same fundamental principles and they should all be kept in mind by those who are investigating the consequences of elastic action and reaction.

124. *Fundamental Photodynamic Nodes.*

The principle of forced vibrations, the theory of subsidence, and the laws of varying density in elastic media, are illustrated by the equation,

$$\left(\frac{L}{r}\right)^{\frac{L}{r}} = \left(\frac{M}{r}\right)^{\frac{i}{c}}$$

$$\therefore \log. L : \log. M :: \frac{i}{c} : \frac{L}{r}$$

L = Laplace's limit of synchronous solar rotation and revolution; M = modulus of light at Sun's surface; r = Sun's semi-diameter; i = locus of mean incipient subsidence for the nebular centre of planetary inertia, (Saturn's mean aphelion); c = central locus of greatest belt-condensation (Earth's semi-axis major).

If we adopt the values for L and M which are given in Note 46, we find i = 9.99861 c. Stockwell's value is about $\frac{1}{10}$ of one per cent. greater, or 10.000059 c.

125. A "*Derivative Oscillation.*"

After announcing the principle of forced vibrations, Herschel continues as follows: "The system may be favorably or unfavorably constituted for such a transfer of periodic movements, or favorably in some of its parts and unfavorably in others; and accordingly as it is the one or the other, the *derivative* oscillation (as it may be termed) will be imperceptible in one case, of appreciable magnitude in another, and even more perceptible in its visible effects than the original cause in a third; of this kind we have an instance in the Moon's acceleration."

A harmonic illustration of this statement is furnished by the lunar disturbance of vertical magnetic force at St. Helena. Von Littrow's estimate of Moon's semi-axis major is 60.2778. Earth's action upon Moon and Moon's reaction should therefore be nearly $\frac{1}{3633}$ as great as its action at its own surface. If the resulting waves or "forced vibrations" are reflected to Earth and resolved, one-half into vertical force and one-half into horizontal force, the consequent disturbance should be $\frac{1}{7267}$. The lunar disturbance of vertical force (Note 121) is $\frac{1}{7194}$; of barometer, $\frac{1}{7299}$. The decimal values are:

Disturbance of vertical force		.0000139
"	" vibrations	.0000138
"	" barometer	.0000137

The derivative oscillation in the horizontal force is obscured by other disturbances.

126. *Relation of Magnetic Disturbances to Thermal Currents.*

The secondary character of the solar disturbances of vertical force at St. Helena is further indicated by a comparison of culminating times. The coincidence of the daily minimum of vertical force with the various maxima of gravitating pressures (Note 120) is only approximate; but the relation both of maximum and of minimum to the culmination of ascending and descending currents is very close. The mean time of maximum temperature is 1 h 39.5 m; of minimum temperature, 17 h 41.6 m; of greatest vertical force, 4 h 4.4 m; of least vertical force, 19 h 55.8 m. Therefore, the vertical force continues to increase for 2 h 24.9 m after the time of greatest daily heat, and to diminish for 2 h 14.2 m after the time of greatest daily cold.

127. *Relation of Barometric to Gravitating Disturbances.*

During the forced vibrations of half-daily terrestrial rotation towards and from the Sun, terrestrial gravity acts on all the heated and otherwise disturbed particles of the atmosphere. The sum of the cyclical accelerations, at St. Helena, is $\frac{16.05 \times 43082^2}{5280} = 5642000$ miles $= \alpha$. The sum of the synchronous "forced oscillations" of rotation towards or from the Sun is cos. $15^\circ\ 56'\ 41'' \times \pi \times 3962.8 = 11970.7$ miles $= \beta$. The mean sum of the barometric pressures of the atmospheric particles is 28.278 inches $= \gamma$. The sum of the mean half-daily disturbances of pressure is $\frac{1}{2}$ $(28.315 - 28.248 + 28.302 - 28.252) = .0585$ inch $= \delta$. The ratio of α to β is nearly the same as that of γ to δ; $\frac{\beta}{\alpha} = .002122$; $\frac{\delta}{\gamma} = .002069$; the deviation from exact accordance being about 2.56 per cent.

128. *Succession of Forced Oscillations.*

The "nascent" velocity of the Sun, or the limiting velocity between complete dissociation and incipient aggregation, is, as we have seen, $\frac{g_0 t_0}{2}$ = velocity of light. On the principle of forced oscillations, the luminiferous æthereal undulations force the sun into rotary oscillations synchronous with the cycles of superficial gravitating activity which would communicate the velocity of light.

The ratio of the mass aggregation at the principal centre of nucleation (Sun), to the mass aggregation at primitive nebular centre (Jupiter), is, as we have seen, the same as the ratio of the rupturing radius-vector of Jupiter to the rupturing radius-vector of Sun. The rupturing energy of the æthereal oscillations is thus traceable to the primitive condition of statical equilibrium, when the two products of mass by rupturing radius were equal.

These two principal masses of the solar system tend to produce a system

of forced oscillations through their common centre of gravity. Circular orbital velocity at their mean centre of gravity has become "nascent" velocity for the mass at the centre of the belt of greatest condensation (Earth).

129. *Radius of Primitive Condensation.*

The importance of the three masses, which were considered in the foregoing note, seems to strengthen the probability that the resulting oscillations are *exactly* recorded in relations of mass, distance and velocity. If such is the case, Earth's semi-axis major may be easily computed.

1. Earth's nascent velocity is $\frac{g_3 t_3}{2} = \frac{32.087 \times 43082}{5280} = 261.81$ miles.

2. The mean locus of the centre of gravity of Sun and Jupiter is $\frac{5.2028}{1047.879 + 1}$ of Earth's semi-axis major.

3. If $\sqrt{g_0 r_0} = 261.81$, Earth's orbital velocity is $\left(\frac{5.2028}{1047.879 + 1}\right)^{\frac{1}{2}} \times 261.81 = 18.4392$ miles per second.

4. This would give, for Earth's semi-axis major, 18.4392×1 year in seconds $\div 2\pi = 92,613,000$ miles.

130. *Paraboloidal Inclination.*

The progression of the stellar-paraboloidal abscissas may be expressed under the form $\xi(\eta\zeta^n)^n$, positive values of n giving centripetal, and negative values giving centrifugal abscissas. The η ordinates are, therefore, modified by ζ, as often as the fundamental abscissa is modified by the *modified* ordinate. The ζ modification seems to imply a cyclical elliptic-influence consequent upon rotation. If ζ is the semi-axis major and η the semi-axis minor of the ellipse, the inclination of the ellipse to the η circle may be readily found by the equation

$$\text{Sec. } \varphi = \frac{\zeta}{\eta} = \frac{1.012974}{.9958534}$$
$$\varphi = 10^\circ\ 32'\ 56''.$$

131. *Other Cometary Hypotheses.*

The hypothesis in Note 114 is only one out of many which might be assumed with nearly equal probability. The great FACT which is to be accounted for is the evidence of paraboloidal influence, extending from the region of the nearest fixed stars to our Sun, and affecting intra-nucleal nodal condensations, revolutions and rotations, through cyclical undulations which are harmonically determined by the inertia of Sun's mass and the velocity of light. I have already shown some of the important modifications which are introduced into the nebular hypothesis by these evidences of paraboloidal or cometoïd subsidence, and I look confidently for the discov-

ery of many others. The connection of comets with meteoric streams will, doubtless, awaken many inquiries respecting stellar groups and stellar motions, some of which may be within the reach and others beyond the reach of future satisfactory solution.

132. *Further Paraboloidal Harmony.*

Let r_a be a fourth proportional to Jupiter's locus of incipient subsidence,* Earth's semi-axis major and Sun's semi-diameter. Then the first three abscissas of Note 46 ($A_0 - A_2$) determine the paraboloid, and there are four groups of 3^2 abscissas, between r_a and the fixed stars, viz.: 9, ($A_3 - A_{11}$), between r_a and Sun's semi-diameter; 9, ($A_{12} - A_{20}$), between Sun's surface and the loci of planetary rupture; 9, ($A_{21} - A_{29}$), within the belt of rupturing loci; 9, ($A_{30} - A_{38}$), between the rupturing loci and *a Centauri.* The influence near the centre of the belt of greatest condensation appears to be also traceable in the ratio between the rupturing abscissas for Earth and Venus, $A_{23} \div A_{22} = 1.77875$,

$$\begin{aligned}
\log.\ 1.77875^{-3} &= -.7503432\\
\log.\ 1.77875^{0} &= .0000000\\
\log.\ 1.77875^{6} &= 1.5006864\\
\log.\ 1.77875^{16} &= 4.0018304\\
\log.\ 1.77875^{30} &= 7.5034320
\end{aligned}$$

By referring to the table in Note 46, it will be seen that the division of the abscissas into four groups of nine each is indicated by these logarithms. It may be well also to observe that 1.77875^4 differs by less than $\frac{1}{10}$ of one per cent. from Stockwell's value for Saturn's mean aphelion estimated in terms of Earth's semi-axis major.

133. *Another Confirmation of Prediction.*

On the 4th of October, 1878, I presented a communication to the American Philosophical Society,† in which I showed that the position of Watson's first intra-Mercurial planet, as computed by Gaillot and Mouchez represented the third intra-Mercurial term of my harmonic series. At the last meeting of the British Association, Prof. Balfour Stewart read a paper in which he gave indications of sun-spot disturbances by a planet, revolving in 24.011 days, and consequently having a semi-axis major of .164. This confirmation, both of my own prediction‡ and of the calculations of the French astronomers, is the more interesting, because the first confirmation of my series was contained in a communication which was made to the Royal Society by Messrs. De la Rue, Stewart and Loewy, forty-one days

* Secular aphelion.
† Proc. Am. Phil. Soc., xviii, 34-6.
‡ *Ib.* xiii, 238.

after I had announced the series to the Philosophical Society and published it in the New York Tribune.* The accordances are as follows:

Prediction.		Confirmation.	
1st interior harmonic term....	.267	De La Rue, S. and L.	.267
3d " " "	.165	Gaillot and Mouchez........	.164
		Stewart	.163

134. *Prout's Hypothesis.*

Clarke (P. Mag. [5] xii, 109-10), gives the results of his re-calculation of atomic weights, which inclines him to look favorably on Prout's hypothesis, although he had previously believed that it had been forever overthrown. Maximilian Gerber (Les Mondes; cited in Chemical News, xliii, 242-3), rejects the hypothesis, but he gives four additional empirical units, which seem to indicate a probability that groups of similar valency may have special common divisors. The varied evidences of the photodynamic importance of hydrogen will doubtless incline chemists to give weighty consideration to Clarke's deliberate opinion, and Gerber's factors may help towards its establishment. The possibility of measuring undulatory *vis viva* by the distance of projection against uniform resistance, as well as by orbital areas, may, perhaps, furnish the requisite clue for reconciling apparent oppositions of indication.

135. *Phyllotactic Atomicity.*

The phyllotactic law distributes leaves and branches evenly around the stems of vegetables, so that all parts of the plant may share in the benefit of heat, air and moisture. In 1849, Dr. Thomas Hill, at the request of Prof. Peirce, showed that the times of planetary revolution are phyllotactic, and the planets are thus distributed around the Sun so evenly as to avoid the destruction of the system by the accumulated perturbations of the great planets.† If the several atomic elements have special systems of æthereal vibrations, it seems reasonable to look for evidences of a phyllotactic harmony which would contribute to the stability of equilibrium in compounds. The following table, which includes about half the known elements, contains multiples of the phyllotactic divisor $\frac{8}{5}$ H, or 1.6 H, compared with Clarke's recalculation of atomic weights.

	Phyllotactic.	Clarke.	Difference.
O	$10 \times 1.6 = 16$	15.963	.037
Fl	$12 \times 1.6 = 19.2$	18.984	.216
Mg	$15 \times 1.6 = 24$	23.951	.049
S	$20 \times 1.6 = 32$	31.984	.016
Cl	$22 \times 1.6 = 35.2$	35.370	.170
Ca	$25 \times 1.6 = 40$	39.990	.010
Ti	$31 \times 1.6 = 49.6$	49.846	.246

* *Ib.* p. 470.

† Proc. Amer. Assoc., vol. 2.

	Phyllotactic.	Clarke.	Difference.
V	32 × 1.6 = 51.2	51.256	.056
Se	49 × 1.6 = 78.4	78.797	.397
Br	50 × 1.6 = 80	79.768	.032
Zr	56 × 1.6 = 89.6	89.367	.233
I	79 × 1.6 = 126.4	126.557	.157
Te	80 × 1.6 = 128	127.960	.040
Cs	83 × 1.6 = 132.8	132.583	.217
Ytter	108 × 1.6 = 172.8	172.761	.039
Bo	7 × 1.6 = 11.2	10.940	.260
Al	17 × 1.6 = 27.2	27.009	.191
Fe	35 × 1.6 = 56	55.913	.087
Ga	43 × 1.6 = 68.8	68.854	.054
Cd	70 × 1.6 = 112	111.770	.230
In	71 × 1.6 = 113.6	113.398	.202
Yt	56 × 1.6 = 89.6	89.816	.216
Ru	65 × 1.6 = 104	104.217	.217
Ro	65 × 1.6 = 104	104.055	.055
Rh	66 × 1.6 = 105.6	105.737	.137
Sb	75 × 1.6 = 120	119.955	.045
Ta	114 × 1.6 = 182.4	182.144	.256
W	115 × 1.6 = 184	183.610	.390
Os	124 × 1.6 = 198.4	198.494	.094
Hg	125 × 1.6 = 200	199.712	.288
Pb	129 × 1.6 = 206.4	206.471	.071
Th	146 × 1.6 = 233.6	233.414	.186
U	149 × 1.6 = 238.4	238.482	.082

The greatest difference in the above table of 33 elements is less than 25 per cent. of the phyllotactic unit. Gerber's longest table, for a single divisor, contains but 25 elements; his greatest difference is more than 36 per cent. of his empirical divisor. If the eight elements which present the greatest phyllotactic difference were rejected, so as to make the tables of the same length, the greatest remaining difference would be less than 15 per cent. of the divisor. The photodynamic approximation is therefore much closer than the empirical.

136. *The Empirical Divisors are Phyllotactic.*

Gerber says that "no simple relation exists among" his divisors, therefore they "have no value in themselves." The relation which he was unable to discover, is phyllotactic, as will be seen by the following comparisons:

	Gerber.	Phyllotactic.	
H	.9997	H	.998
D_1	.769	$\frac{5}{13} \times 2$ H	.768
D_2	1.995	2 H	1.996
D_3	1.559	$\frac{5}{4} \times \frac{5}{4}$ H	1.559
D_4	1.245	[illegible] × [illegible] H	1.247

The first six phyllotactic numbers are 1, 2, 3, 5, 8, 13; the third does not appear in the formation of the theoretical divisors, but the others are all employed. The simple phyllotactic relation of all the divisors to H, shows that they *have* "value in themselves."

137. *Mutual Phyllotaxy.*

Upon examining the mutual relations of the above phyllotactic divisors, it will be seen that $D_1 = \frac{8}{13} D_2 = 2 \times \frac{3}{5} \times \frac{8}{13} D_3 = \frac{8}{13} D_4$; $D_2 = 2 \times \frac{3}{5} \times \frac{3}{5} D_3 = 2^3 \times \frac{3}{5} D_4$; $D_3 = \frac{5}{2} \times \frac{1}{2} D_4$; $D_4 = \sqrt{H D_3}$. These varied provisions for the stability of cyclical equilibrium, in all possible varieties of intra-molecular æthereal movement, show that the command, "Let there be light," manifested its formative power of organization as soon as material atoms were set in motion. The appearance of the first five phyllotactic numbers, 1, 2, 3, 5, 8, in crystallization, furnishes a step from inorganic to organic morphology, giving new meaning to the landscapes on our frosted window-panes, as well as to the protective mimicry of vegetables and animals, as illustrations of the "distributive ratio" which controls alike light-waves, atomic inertia, crystalline structure, organic growth, planetary configuration and interstellar action.

138. *Relations of the Water Molecules.*

The importance of oxygen and hydrogen, both in mutual combination and in connection with other elements, suggests the following comparative grouping of Clarke's table of atomic weights:

O — 16;	H — 1.0023.	Difference.	O — 16;	H — 1.0023.	Difference.
Br	79.951	.049	Bi	208.001	.001
I	126.848	.152	Pb	206.946	.054
Mg	24.014	.014	Mn	54.029	.029
Zn	65.054	.054	Fe	56.042	.042
Cs	132.918	.082	Ni	58.062	.062
Ag	107.923	.077	Co	59.023	.023
Tl	204.183	.183	Bo	10.966	.034
Se	78.978	.022	Ga	68.963	.037
Mo	95.747	.253	Ce	140.747	.253
W	184.032	.032	Yttr	90 023	.023
U	239.030	.030	Ytter	173.158	.158
P	31.029	.029	La	138.844	.156
Cd	112.027	.027	Di	144.906	.094
Hg	200.171	.171	Th	233.951	.049
Ba	137.007	.007	Pt	194,867	.133
C*	12.001	.001	Ir	193.094	.094
Ti	49.961	.039	Os	198.951	.049
Sn	117.968	.032	Pd	105.981	.019
In	113,659	.341			

H = 1; O = 15.9633.		Difference.	H = 1; O = 15.9633.		Difference.
Fl	18.984	.016	Zr	89.367	.367
Cl	35.370	.370	N	14.021	.021
Li	7.007	.007	Sb	119.955	.045
Gl	9.085	.085	Ta	182.144	.144
Na	22.998	.002	Sc	43.980	.020
K	39.019	.019	Al	27.009	.009
Rb	85.251	.251	V	51.256	.256
S	31.984	.016	As	74.918	.082
Te	127.960	.040	Cu	63.173	.173
Cr	52.009	.009	Er	165.891	.109
Ca	39.990	.010	Rh	104.055	.055
Sr	87.374	.374	Ru	104.217	.217
Si	28.195	.195	Au	196.155	.155

The above tables seem to show that, if Prout's law is correct, the value of the oxygen atom has been more accurately determined than that of the hydrogen atom. The deviations of Mo, In, Ce, Cl, Rb, Sr, Zr, and V, are so great as to require some explanation, which may, perhaps, be found in phyllotactic or harmonic influence.

139. *Further Evidence of Phyllotaxy.*

Upon further examination of Gerber's tables, I find a still closer agreement with rigidly phyllotactic divisors Taking the mean of the estimated atomic weights, when two are given, his values should be as follows: $D_1 = 655.28 \div 853 = .7681$; $D_2 = 1440.4 \div 722 = 1.9950$, $D_3 = 646.2$[illegible] $\div 415 = 1.5571$; $D_4 = 2763.05 \div 2218 = 1.2457$; $H = 1.3\ D_1 = .99$[illegible] Clarke's values for the atomicities, when grouped in the same way as Gerber's, give $D_1 = 656.212 \div 853 = .7693$; $D_2 = 1437.96 \div 721 = 1.9944$ $D_3 = 643.53 \div 413 = 1.5582$; $D_4 = 2752.051 \div 2208 = 1.2464$; $H = 1$[illegible] $D_1 = 1.0001$. The following table shows the nearness of agreement between the empirical and the phyllotactic divisors:

Phyllotactic.		Gerber.	Clarke.
$H = \frac{1}{16} O$	.9977	.9986	1.0001
$D_1 = \frac{10}{13} H$	.7675	.7681	.7693
$D_2 = 2\ H$	1.9954	1.9950	1.9944
$D_3 = \frac{5}{4}\ D_4$	1.5589	1.5571	1.5582
$D_4 = \frac{5}{8}\ D_2$	1.2471	1.2457	1.2464

140. "*Elasticity.*"

"Sir W. Thomson is led from the consideration of various experiments with fluids and solids and the study of smoke rings to speculate upon elasticity as an evidence of motion. The kinetic theory of gases requires that the molecule or atom shall be elastic. 'But this kinetic th[illegible]

forward to a greater generalization which shall include elasticity as a form of motion."—J. T., in *Am. Jour. of Science*, Nov. 1881.

My first physical paper (Proc. Am. Phil. Soc., ix, 283-8), deduced approximate values of solar mass and distance from the combined action of daily rotation, yearly revolution and atmospheric elasticity. All my subsequent radiodynamic investigations have been based upon the consideration of the various forms of harmonic relation which *ought* to follow from the undulations of an all-pervading elastic medium, such as the luminiferous æther is generally supposed to be.

141. *Harmonic Spectra.*

Schuster (*Proc. Roy. Soc.*, xxxi, 337-47), discusses the probability of accidental harmonic coincidences in spectral wave-lengths, giving the following summary of his results for the iron spectrum :—

"1. *There is a real cause acting in a direction opposed to the law of harmonic ratios, so far as fractions formed by numbers smaller than seventy are concerned.*

"2. *After elimination of the first cause a tendency appears for fractions formed by two lines to cluster round harmonic ratios.*

"3. *Most probably some law hitherto undiscovered exists, which in special cases resolves itself into the law of harmonic ratios.*"

The comparison between the planetary harmonic roots and the spectral harmonic quotients (Note 37), suggests the probability that the opposition to strict harmonic ratios may be due to differences of inertia in the wave-systems, which would be more rigidly harmonic were it not for such differences. The simple tendency of all elastic media to harmonic vibrations would then be the general law, instead of a law which becomes harmonic "in special cases."

In waves which are propagated with such rapidity as those of light, it seems reasonable that there may be large factors of harmonic length, which are modified by smaller disturbing elements. Schuster's analysis does not reach such cases as are given in Notes 36, and 39–42. Note 36 gives 11 harmonic divisors, which deviate from the observed divisors by a mean amount of less than $\frac{1}{10}$ of one per cent. The greatest difference is in the C line, where the harmonic divisor is 1.1580, the observed divisor being 1.1592, giving a deviation of [illegible] of one per cent. In Note 39, the greatest difference between either of the harmonic lines and the corresponding basic line is $\frac{1}{8}$ of one per cent. In Note 41 the greatest difference is $\frac{1}{20}$ of one per cent. In Note 42, $\frac{1}{14}$ of one per cent.

142. *The Magnesium Spectra.*

Liveing and Dewar (Proc. Roy. Soc., xxxii, 189–203), give some results of their investigations on the spectrum of magnesium, which seem to strengthen the probability of large harmonic factors, modified by small disturbances. The only two single lines which are found in the flame-spectrum, the arc-spectrum and the spark-spectrum, have wave-lengths

of 2850 and 4570, respectively. These represent, approximately, the phyllotactic numbers 5 and 8, viz.:

Phyllotactic.	Observed.
2854	2850
4566	4570

In the arc-spectrum and spark-spectrum, there is "a very striking group of two very strong lines at wave-lengths about 2801 and 2794," and "one line common to the arc and spark at wave-length 4703" which "does not appear in Angstrom's table." The difference between the "two very strong lines" has modified the other lines, as shown below :—

Harmonic.	Observed.
$7 \times 399 = 2793$	2794
$7 \times 400 = 2800$	2801
$7 \times 407 = 2849$	2850
$7 \times 653 = 4571$	4570
$7 \times 672 = 4704$	4703

The greatest difference is $\frac{1}{7}$ and the mean difference is $\frac{1}{35}$ of the harmonic divisor. If there were no law controlling the approximations, the probable maximum difference would be $\frac{1}{2}$ and the mean difference would be .25 of the divisor.

143. *The Special Phyllotactic Elements.*

The elements which cannot be simply grouped with O and H, within the limits of probable error (Note 138), have the following phyllotactic relations to oxygen,

	Observed.	Phyllotactic.	Difference.
Mo	$95.747 \times \frac{1}{16}$ O	$2^5 \times 3 = 96.$	.253
In	$113.659 \times \frac{1}{16}$ O	$7 \times 13 \times \frac{5}{4} = 113.75$	.091
Ce	$140.747 \times \frac{1}{16}$ O	$3 \times 61 \times \frac{10}{13} = 140.769$	.022
Cl	$35.451 \times \frac{1}{16}$ O	$2 \times 23 \times \frac{10}{13} = 35.385$	.066
Rb	$85.529 \times \frac{1}{16}$ O	$3 \times 37 \times \frac{10}{13} = 85.385$	.144
Sr	$87.575 \times \frac{1}{16}$ O	$5^2 \times 7 \times \frac{1}{2} = 87.5$	.075
Zr	$89.573 \times \frac{1}{16}$ O	$11 \times 13 \times \frac{5}{8} = 89.375$	.198
V	$51.373 \times \frac{1}{16}$ O	$41 \times \frac{5}{4} = 51.25$	.123

144. *Analysis of the Hydrogen Spectrum.*

It seems reasonable to look for clearer evidence of undisturbed or slightly modified harmonic influence in hydrogen, than in any of the heavier elements. Accordingly Professor Johnstone Stoney has "shown that three out of the four lines in the visible part of the spectrum have wave lengths which, to a high degree of accuracy, are in the ratios of 20 : 27 : 32." I find, moreover, that three of the lines are in simple geometric ratio, as will be seen by the following comparison :

Theoretical Harmonic Lines.	Observed.
$\alpha = (2 \times 3)^3 \times 30.379 = 6561.8$	6561.8
$\beta = 5 \times 2^5 \times 30.379 = 4860.6$	4860.6
$\gamma = (\delta^2 \beta)^{\frac{1}{3}} = 4340.1$	4340.
$\delta = 5 \times 3^3 \times 30.379 = 4101.1$	4101.2

The extreme lines are phyllotactic, δ being $\frac{5}{8}$ of a. The greatest discrepancy is $\frac{1}{40}$ of one per cent. which is unquestionably within the limits of probable error.

145. *Application of Schuster's Tests.*

The ratio between the hydrogen lines a and δ is between $\frac{5}{8}$ and $\frac{2}{3}$.

$$a \div \delta = a = 1.59997$$
$$8 \div 5 = b = 1.60000$$
$$3 \div 2 = c = 1.50000$$
$$b - c = d = .10000$$
$$b - a = e = .00003$$

$e \div d = \frac{3}{10000}$, or less than $\frac{1}{33}$ of one per cent. of the probable error.

The ratio between γ and δ is between $\frac{17}{18}$ and $\frac{86}{91}$

$$\gamma \div \delta = a_1 = 1.058227$$
$$18 \div 17 = b_1 = 1.058824$$
$$91 \div 86 = c_1 = 1.058140$$
$$b_1 - c_1 = d_1 = .000684$$
$$a_1 - c_1 = e_1 = .000087$$

$e_1 \div d_1 = \frac{29}{228}$, the probable error being $\pm \frac{57}{228}$.

The ratio between a and β is between $\frac{20}{27}$ and $\frac{57}{77}$.

$$a \div \beta = a_2 = 1.350165$$
$$77 \div 57 = b_2 = 1.350877$$
$$27 \div 20 = c_2 = 1.350000$$
$$b_2 - c_2 = d_2 = .000877$$
$$a_2 - c_2 = e_2 = .000165$$

$e_2 \div d_2 = \frac{165}{877}$, the probable error being $\pm \frac{219}{877}$. If we were to stop here, the test would be pronounced satisfactory, and the evidence of harmonic influences in which all the lines are involved would be conclusive. But if we try another mode of grouping the result will be different.

The ratio between β and δ is between $\frac{27}{32}$ and $\frac{65}{77}$.

$$\beta \div \delta = a_3 = 1.185009$$
$$77 \div 65 = b_3 = 1.184616$$
$$32 \div 27 = c_3 = 1.185185$$
$$c_3 - b_3 = d_3 = .000569$$
$$c_3 - a_3 = e_3 = .000166$$

$e_3 \div d_3 = \frac{166}{569}$, the probable error being only $\pm \frac{142}{569}$. Therefore the test fails in this case.

The ratio between β and γ is between $\frac{25}{28}$ and $\frac{67}{75}$.

$$\beta \div \gamma = a_4 = 1.119816$$
$$28 \div 25 = b_4 = 1.120000$$
$$75 \div 67 = c_4 = 1.119403$$
$$b_4 - c_4 = d_4 = .000597$$
$$b_4 - a_4 = e_4 = .000184$$

$e_4 \div d_4 = \frac{184}{597}$, the probable error being only $\pm \frac{149}{597}$. Therefore the test fails in this case also.

The ratio between α and γ is between $\frac{62}{41}$ and $\frac{65}{43}$.

$$\begin{aligned}
\alpha \div \gamma &= a_5 = 1.511936 \\
62 \div 41 &= b_5 = 1.512195 \\
65 \div 43 &= c_5 = 1.511628 \\
b_5 - c_5 &= d_5 = .000567 \\
b_5 - a_5 &= e_5 = .000259
\end{aligned}$$

$e_5 \div d_5 = \frac{37}{81}$, the probable error being only $\pm \frac{20}{81}$. The test, therefore, fails again, the number of failures in the whole comparison being equal to the number of confirmations. Hence it is evident that Schuster's criterion is insufficient, at least when the probable errors of observation are not satisfactorily ascertained. Even if the probable errors were known, the proper application of the test would require supplementary calculations of such intricacy as to make it practically inoperative.

146. *Modifications of the Test.*

By increasing the magnitude of the harmonic ratios the test may sometimes be made to indicate a probability. For example, $\beta \div \gamma$ is between $\frac{6}{5}$ and $\frac{7}{6}$. These values give $d_4 = .033333$; $e_4 = .000184$, $e_4 \div d_4 = \frac{1}{181}$, which is less than $\frac{1}{45}$ of the probable error. In like manner $\alpha \div \gamma$ is between $\frac{3}{2}$ and $\frac{4}{3}$. These values give $d_5 = .166667$; $e_5 = .011936$; $e_5 \div d_5 = \frac{1119}{15625}$, which is less than $\frac{4}{13}$ of the probable error. These results seem to indicate the propriety of harmonic comparisons between terms which are unquestionably of the same order of magnitude. Thus in Schuster's calculation (loc. cit., p. 338), the ratio .96476 lies between $\frac{55}{57}$ and $\frac{55}{58}$, the difference between these two fractions being .016636. The difference of the fraction in the sodium spectrum from the nearest of these comparative fractions is .000152, which is only .00914 of the difference between the fractions themselves, or less than $\frac{1}{27}$ of the probable error.

If a supposed harmonic relation can be represented by a fraction with terms of a single digit, Schuster's test might fail even with the above modification, provided the probable error should be $> \frac{1}{4} \times \frac{1}{8} \times \frac{1}{9}$; if the terms are of two digits, it would not be trustworthy if the probable error was $> \frac{1}{4} \times \frac{1}{98} \times \frac{1}{99}$. If the modifications of *vis viva* in synchronous wave systems are of the same order of magnitude as the variations of planetary eccentricity, the limit of probable error would be at least $\frac{1}{8}$, instead of $\frac{1}{4}$, of the difference between adjacent fractions which have a common numerator. This would be the case for each of the compared pairs of wave lengths, the probability for the entire system being equivalent to the product of all the independent probabilities.

All estimates of abstract probability, in such cases, should be greatly increased by the *a priori* probability, or even the mathematical necessity, that synchronous undulations in elastic media *must be* harmonic. In view of this consideration, the indications of a harmonic tendency pervading an entire system, such as I have pointed out in many of my compar-

sons, are far more significant than any conclusions that can be drawn from more restricted investigations.

Whatever test may be applied, it should always be remembered that the failure to discover a harmonic influence between any two given lines does not affect, in the slightest degree, the evidences of harmonic influence between other lines. The failing cases are entitled to no weight in drawing the final conclusion. We should, therefore, have been justified in stopping our examination of the observed lines in the hydrogen spectrum, as soon as we found that α is harmonically connected with β and δ, and that γ is similarly connected with δ. Even if subsequent discussions had failed to show any probable evidence of harmony between β and γ, β and δ, α and γ, the fact that there are such harmonies operating through the relations of the intermediate to the extreme wave-lengths, would have been unshaken.

147. *Uncertainties of Measurement.*

The influence of probable errors of observation upon the validity of Schuster's criterion may be illustrated by applying it to two of the different values which have been found for the Fraunhofer lines A, B and C. Angstrom's measurements are taken from *Schellen's Spectrum Analysis*, p. 168; Gibbs's, from *Am. Jour. Science*, [2] xliii, 4.

	Gibbs.		Angstrom.
A	761.20		760.09
B	687.49		686.68
C	656.77		656.18
$A \div B = a$	1.107216		1.106906
$b = 31 \div 28$	1.107143	$31 \div 28$	1.107143
$c = 72 \div 65$	1.107692	$83 \div 75$	1.106666
$c - b = d$	.000549	$b - c$	.000477
$a - b = e$	.000073	$b - a$	.000237
$e \div d$	$73 \div 549$		$79 \div 159$
Probable error	$137 \div 549$		$39 \div 159$
$B \div C = a_1$	1.046776		1.046481
$b_1 = 45 \div 43$	1.046512	$45 \div 43$	1.046512
$c_1 = 67 \div 64$	1.046875	$68 \div 65$	1.046154
$c_1 - b_1 = d_1$	.000363		.000358
$c_1 - a_1 = e_1$	.000109	$b_1 - a_1$	.000031
$e_1 \div d_1$	$109 \div 363$		$31 \div 358$
Probable error	$90 \div 363$		$89 \div 358$

Hence the criterion indicates a harmony of vibration, both between the A and B lines, according to Gibbs, and between the B and C lines, according to Schellen. The *a priori* probability or certainty that there must be such a harmony, lends confidence to the greater accuracy of Gibbs's measurement of the A line, and of Schellen's measurement of the C line. If such allowance as I have proposed is made for that probability, the harmony is shown by Gibbs in both comparisons.

148. *The Fraunhofer Harmonies.*

The general accuracy of Gibbs is confirmed by the fact that his measurements indicate harmonies among the principal Fraunhofer lines, as is shown in the following table. They all bear the test of Schuster's criterion, with the exception which was stated in the foregoing note.

Harmonies.	Gibbs.	Difference.
A 761.20	A 761.20	
$\frac{28}{31}$ A 687.54	B 687.49	.05
$\frac{64}{67}$ B 656.75	C 656.77	.02
$\frac{44}{49}$ C 589.73	D_γ 589.74	.01
$\frac{76}{85}$ D 527.29	E 527.38	.09
$\frac{89}{72}$ H_2 486.68	F 486.52	.16
$\frac{23}{21}$ H_2 431.24	G 431.03	.21
$\frac{15}{29}$ A 393.72	H_2 393.59	.13

The greatest difference is only $\frac{1}{20}$ of one per cent., in the G line.

149. *Proper Use of Harmonic Tests.*

In systems of waves which are propagated with such frequency as the undulations of light, it may, perhaps, be impossible to devise any criterion which will show whether any two given waves are really harmonic. But if we consider that undulations which are not harmonic are continually tending to destroy each other, various useful tests may be found, which will serve as guides for the approximate determination of harmonies that must really exist. For example, if there are two harmonic light-waves, the slower oscillating 1670 times, while the swifter oscillates 1843 times, there will be more than 300,000,000,000 coincidences of phase per second, and yet Schuster's method would lead us to suppose that there is no harmony. The ratio $\frac{1670}{1843}$, is equivalent to .906131, which is between $\frac{29}{32}$ and $\frac{77}{85}$.

29 ÷ 32	.906250
77 ÷ 85	.905882
Difference	.000368
.906250 — .906131	.000119
Ratio of Differences 119 ÷368	.324
Probable Error	.250

150. *Successive Harmonies.*

The following table shows that Angstrom's measurements indicate harmonic undulations, which present more than 600,000,000,000 coincidences of phase per second in successive lines:

Wave-length.	Log. w. l.	Log. ratio,	Ratio.
A 760.09	2.8808650	$\bar{1}$.9755619	501 / 530
a 718.50	2.8564269	$\bar{1}$.9803266	410 / 429
B 686.68	2.8367535	$\bar{1}$.9802695	710 / 743
C 656.18	2.8170230	$\bar{1}$.9534617	389 / 433
D_1 589.50	2.7704847	$\bar{1}$.9512343	446 / 499

Wave-length.	Log. w. l.	Log. ratio,	Ratio.
E. 526.89	2.7217190	$\bar{1}.9919387$	427 / 435
b_2 517.20	2.7136577	$\bar{1}.9730311$	359 / 382
F 486.06	2.6866888	$\bar{1}.9475091$	288 / 325
G 430.73	2.6341979	$\bar{1}.9787118$	418 / 439
h 410.12	2.6129097	$\bar{1}.9856655$	149 / 154
H_1 396.80	2.5985752	$\bar{1}.9961108$	667 / 673
H_2 393.26	2.5946860		

Schellen's table gives 393.28 for the wave-length of H_2. His other values are precisely the same as the harmonic lengths which are given here. The greatest interval between the successive coincidences of phase in the propagation of the waves which represent any two adjacent lines, is less than $\frac{1}{30}$ of an inch.

Some of the closer lines precisely represent simple geometric progressions within the limits of uncertainty of observation. The middle D line, according to Gibbs, is a geometrical mean between the extreme lines.

Gibbs.	Geometric.	Log.
β 590.04	590.038	2.7708800
γ 589.74	589.736	2.7706576
α 589.43	589.434	2.7704352

By making $r = \frac{953}{952}$, we find that the three b lines are in geometrical progression :

Schellen.	Geometric.	Log.
b_1 518.30	ar_3 518.296	2.7145778
b_2 517.20	ar 517.209	2.7136658
b_3 516.67	a 516.666	2.7132098

Gibbs, in *Johnsons' Cyclopedia*, gives four b lines, the additional line being also geometrically determined :

Gibbs.	Geometric.	Log.
b_1 518.31	ar^3 518.31	2.7145896
b_2 517.22	ar 517.22	2.7136776
b_3 516.85	$ar^{\frac{1}{3}}$ 516.86	2.7133736
b_4 516.69	a 516.68	2.7132216

151. *Conjoined Harmonics.*

The indications of geometrical progression in the D and b groups suggest the propriety of looking for similar evidence among the remaining lines. The relations which I have pointed out between æthereal and planetary nodes (Note 37), led me to look to the inertia of Sun and Jupiter as an important source of nodal influence upon æthereal waves. Light-waves would traverse a trajectory equivalent to that of Earth's daily synodic rotation 5.202798 × 365.25636 = 1900.355 times, during the interval which would be required for them to traverse one equivalent to Ju-

piter's orbit. If we suppose the length of each wave to be increased in the ratio $r = (1901.355 \div 1900.355)^{\frac{1}{4}}$, we get the following approximations :

Geometric wave-lengths.		Log. w. l.	Log. r^n.	Schellen.
$A = ar^{428}$	760.10	2.8808707	.0244495	760.09
$a = Br^{344}$	718.49	2.8564212	.0196510	718.50
$B = Cr^{345}$	686.70	2.8367702	.0197081	686.68
$C = D_1r^{815}$	656.24	2.8170621	.0465569	656.18
$D = Er^{854}$	589.53	2.7705052	.0487848	589.50
$E = b_2r^{141}$	526.89	2.7217204	.0080546	526.89
$b_2 = Fr^{472}$	517.21	2.7136658	.0269630	517.20
$F = Gr^{919}$	486.07	2.6867028	.0524979	486.06
$G = hr^{373}$	430.73	2.6342049	.0213076	430.72
$h = H_1r^{251}$	410.11	2.6128973	.0143384	410.12
$H_1 = H_2r^{68}$	396.79	2.5985589	.0038845	396.80
H_2	393.26	2.5946744		393.28

The lines can be grouped in three sets :—1. A, a, B, D_1 ; 2. C, b_2, F, h ; 3. E, G, H_1, H_2. All members of the first and third groups are connected with the other members of their own groups by some power of r^4 ; those of the second group, by some power of r^2 ; the members of the third group being connected with those of the first by some odd power of r^2 ; those of the second with those of either of the other groups, by odd powers of r. Three lines of the middle group, C, F, h, are hydrogen lines. The boundaries of the group are phyllotactic ; 5 C = 8 h.

152. *Interpretation and Mass-Relations.*

The considerations involved in the foregoing notes were orbital velocity $\left(v_0 \propto \sqrt{\frac{1}{r}}\right)$, gravitating velocity, $\left(v_1 = g \propto \frac{1}{r^2}\right)$, the constant velocity of light, (v_2) and inertia, or mass. Orbital velocity varies as the fourth root of gravitating velocity, $\left(v_0 \propto v_1^{\frac{1}{4}}\right)$; hence the ratio of increase varies as the fourth root of the relative disturbance of inertia, $r = (1901.355 \div 1900.355)^{\frac{1}{4}}$.

If we take the constant relation between gravitating and photodynamic action at Earth's surface as a unit, $(p_3 = 1)$, there should be some harmonic relation between p_3 and Jupiter's incipient perturbation, $(p_5 = r^4 - 1)$, dependent on the masses of Earth, (m_3), and Jupiter, (m_5). Earth's reaction upon its linear centre of oscillation, relative to the centre of the "line of force" which connects it with Jupiter, is exerted at $(\frac{1}{3}$ of $\frac{1}{2}) = \frac{1}{6}$ of the distance of Jupiter's action upon Earth, consequently with a six-fold relative efficiency. Accordingly we find :

$$\frac{m_3}{m_5} = \frac{6\,p_5}{p_3} = \frac{6}{1900.355} = \frac{1}{316.726}$$

$$\frac{m_0}{m_3} = 316.726 \times 1047.879 = 331890$$

$$\rho_3 = 92{,}796{,}300 \text{ miles.}$$

This value of ρ_3 differs by less than $\frac{1}{15}$ of one per cent. from the mean of various mechanical estimates, which was given in Note 15.

153. *Linear Harmonics.*

The harmonies to which Schuster refers, in the third conclusion of his summary, seem to be linear rather than geometric. If we omit the specially phyllotactic lines C and *h*, together with the secondary lines of the D and *b* groups, the percentages of the geometric, Schellen and Gibbs tables give the following coincidences of harmonic tendency :

	Geometric.		Schellen.		Gibbs.	
A	760.10	1933 — .16	760.09	1933 — .31	760.40	1933 + .38
a	718.49	1827 + .03	718.50	1827 — .06	718.47	1827 — .23
B	686.70	1746 + .21	686.68	1746 + .03	686.71	1746 + .02
D	589.53	1499 + .10	589.50	1499 — .07	589.51	1499 — .12
E	526.89	1340 — .18	526.89	1339 — .27	526.96	1340 — .16
b_2	517.21	1315 + .19	517.20	1315 + .09	517.22	1315 + .08
F	486.07	1236 + .03	486.06	1236 — .09	486.07	1236 — .12
G	430.73	1095 + .29	430.72	1095 + .20	430.73	1095 + .17
H_1	396.79	1009 — .03	396.86	1009 — .05	396.81	1099 — .02
H_2	393.26	1000	393.28	1000	393.30	1000

The only instances in which the deviations from exact harmony exceed $\frac{1}{4}$ of the right hand unit, are the G line in the geometric table, the A and E lines of Schellen, and the A line of Gibbs.

154. *Interstellar Phyllotaxy.*

The interstellar abscissas, Note 46, present the following phyllotactic features :

1. The determination of the paraboloid requires 3 abscissas.
2. The whole number of abscissas, between the vertex and the stellar region, is 3×13.
3. The abscissas between A_2 and A_{39} are divided into two groups, each group containing 2×3^2 abscissas.
4. Each group has two equal subdivisions ; the inner representing tendencies to condensation, the outer giving no present evidence of such tendency, except in comets, meteors and possibly asteroids.

155. *Distance of α Centauri and its connection with the Interstellar Paraboloid.*

Newcomb gives estimates of the parallax of *α Centauri*, ranging between 0″.48 and 1″.96. The mean of Henderson's observations, in 1832–3, as deduced by himself, was 1″.16 ± .11. Peters, from the same observations, found 1″.14 ± .11. Henderson obtained 0″.913 from Maclear's observations in 1839–40 ; Peters, 0″.976 ± .064 from the same ; Maclear, 0″.919 ± .034 from declinations in 1842, 1844 and 1848 ; Moesta, 0″.880 ± .068 from declinations in 1860–4. There is, therefore, an uncertainty as to the

actual distance, which is of the same order of magnitude as planetary eccentricities. If this fact should be thought to diminish the probability of a kinetic bond between the photodynamic paraboloid and the fixed stars, it will be well to bear in mind the following considerations :

1. If there is an all pervading interstellar medium, which is both material and elastic, all its persistent oscillations *must be* cyclically harmonic in some way or other.

2. All such permanent oscillations must be dependent upon or associated with permanent masses and velocities.

3. The mass and velocity from which the paraboloidal abscissas were deduced, are the mass of the sun and the velocity of light.

4. The coördinates indicate a solar motion in space, which is closely accordant with Herschel's estimated velocity. (Note 112.)

5. The abscissas locate regions of incipient subsidence, which account for the formation of the several planetary belts, in accordance with Herschel's interpretation of the nebular hypothesis.

6. The abscissas are manifoldly grouped, in ways that are phyllotactically and otherwise harmonically symmetrical, as might be looked for in a medium like the supposed luminiferous æther.

7. The last phyllotactic abscissa, A_{38}, is a fourth proportional to Sun's radius, Laplace's limit, and the solar modulus of light.

8. The paraboloid fixes Sun's position, relatively to some other important stars in the Milky Way. (Note 114.)

9. These are the most far-reaching indications of an unbroken chain of kinetic influences, that have ever been published.

10. Being based upon the greatest mass and the greatest intercosmical velocity of which we have any measurable knowledge, the law of parsimony gives an *a priori* presumption that the chain may extend to other masses of the same order of magnitude as the Sun.

11. The next abscissa to the solar phyllotactic series, A_{39}, is in the region of the fixed stars, its locus being, within the limit of probable error, ($\pm$ .25), the same as that of *α Centauri*.

12. The terminal locus is not only within, but *far* within, the limits of probable error. Its accordance with *α Centauri* may be exact ; it is almost impossible that the deviation from precise accordance can be so great as 8 per cent., and such a deviation could be easily explained by stellar orbital motions.

13. The second stellar abscissa, A_{40}, indicates a distance corresponding to Bessel's estimate of the parallax of 61 *Cygni.*

14. Whatever may be thought of the last three indications, the first ten are plain, unmistakable and incontrovertible.

156. *Correlations of Planetary Mass and Distance.*

Stockwell closes the introduction to his "Memoir on the Secular Variations of the Elements of the Orbits of the Eight Principal Planets," in the following words :

"The idea is thus suggested of the existence of a system of bodies in

which the masses of the different bodies are so adjusted to their mean distances as to insure to the system a greater degree of permanence than would be possible by any other distribution of masses. The mathematical expression of a criterion for such distribution of masses has not yet been fully developed; and the pending illustrations have been introduced here, more for the purpose of calling the attention of mathematicians and astronomers to this interesting problem than for any certain light we have yet been able to obtain in regard to its solution."

When I began my investigation of the harmonies which illustrate the laws of æthereal elasticity, the only published evidence of any connection between planetary mass and distance was Alexander's approximate equality between the products of the masses of Jupiter and Saturn by the squares of their respective major axes:

$$\text{Jupiter } \tfrac{1}{1047.879} \times 5.202798^2 = .025832.$$
$$\text{Saturn } \tfrac{1}{3501.6} \times 9.538852^2 = .025985.$$

Laplace, however, had indicated elements of stability in the sums of various products, and had demonstrated the tendency of approximate synchronisms to become exact; Herschel had shown that "subsidence, and the central aggregation consequent on subsidence, may go on quite as well among a multitude of discrete bodies under the influence of mutual attraction and feeble or partially opposing projectile motions, as among the particles of a gaseous fluid"; * various physical investigations, based upon propositions in Newton's Principia, had indicated the fact that *all persistent oscillations or cyclical motions in elastic media* MUST BE *subject to harmonic laws.*

In studying Herschel's statements of the nebular hypothesis, it soon became evident that Sun, at the principal centre of nucleation, Earth, at the centre of the belt of greatest condensation, and Jupiter, at the centre of the primitive nebula, had some important common relations which had exerted a controlling influence over the other cosmical masses. The four following are specially noteworthy.

1. The "nascent velocity" of Sun, $\frac{gt}{2}$†, *is equivalent to the velocity of light.*

2. The nascent velocities of Earth and Jupiter are nearly equal.

3. Earth's nascent velocity is about 3 per cent. less, while Jupiter's appears to be slightly greater, than the limit of possible circular-orbital velocity, $\sqrt{gr}$ at Sun's surface.

4. The aggregate orbital *vis viva* of Earth, vv_3, and Jupiter, vv_5, is a simple function of mean distance from Sun, d, and orbital time, $d^{\frac{3}{2}}$.

$$\left(\frac{d_5}{d_3}\right)^{\frac{5}{2}} = \left(\frac{5.202798}{1}\right)^{\frac{5}{2}} = 61.7436 = 1 + 60.7436 = vv_3 + vv_5 \quad (1)$$

* *Outlines of Astronomy*, Sect. 871.

† t being time of solar rotation, and g being the acceleration of superficial gravitation.

In the above equation, and elsewhere in the present note, Earth's mass and semi-axis major are taken as the units of mass and distance.

In studying the results of nebular "subsidence," let α represent the locus of incipient belt-subsidence or secular aphelion ; β, the locus of mean belt subsidence or mean aphelion ; γ, the semi-axis major ; δ, the mean locus of belt-rupture or mean perihelion ; ε, the locus of incipient belt-rupture or secular perihelion ; subscript 0, 1, 2, 3, 4, 5, 6, 7, 8, Sun and the principal planets in their order, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune ; m, mass.

$$m_0 : m_5 : : \varepsilon_5 : \varepsilon_0 : : 1047.879 : 1 \tag{2}$$

According to Stockwell (op. cit. p. 38), $\varepsilon_5 = .9391726\,\gamma_5$. Therefore $\gamma_3 = 1047.879\,\varepsilon_0 \div (5.202798 \times .9391726) = 214.4513\,\varepsilon_0$ and $\gamma_5 = 1115.74\,\varepsilon_0$. Mass being represented by the product of mean orbital *vis viva* by mean distance, we find, from (1) and (2),

$$m_3 : m_5 : : 1 \times 1 : 60.7436 \times 5.202798 : : 1 : 316.0366 \tag{3}$$

$$m_0 : m_3 : : (316.0366 \times 1047.879 = 331668) : 1 \tag{4}$$

Earth's chief companion planet, Venus, shows the influence of incipient subsidence-aggregation.

$$m_3 : m_2 : : \gamma_3 : \alpha_2 : : 1 : .77442 \tag{5}$$

$$m_0 : m_2 : : (331668 \div .77442 = 427630) : 1 \tag{6}$$

Jupiter's chief companion planet, Saturn, shows the combined influence of modified belt-rupture and secular stability.

$$m_5 : m_6 : : \beta_6\gamma_6 : \beta_5\gamma_5 : : 9.077645 \times 9.538852 : 4.978245 \times 5.202798 : : 3.3432 : 1 \tag{7}$$

$$m_0 : m_6 : : (3.3432 \times 1047.879 = 3503.22) : 1 \tag{8}$$

The outer planet of the dense belt, Mars, shows the influence of modified subsidence at the centre of nebular planetary inertia (Saturn), combined with that of incipient subsidence at the centre of the belt (Earth).

$$m_3 : m_4 : : \beta_6 : \alpha_3 : : 10 : 1.0677352 : : 9.3657 : 1 \tag{9}$$

$$m_0 : m_4 : : (9.3657 \times 331668 = 3101613) : 1 \tag{10}$$

The two outer planets of the system show the combined influence of nodes of subsidence, rupture, and condensation.

$$m_8 : m_3 : : (\delta_8 - \alpha_3)\gamma_8 : (\delta_8 + \alpha_7)\gamma_3 : : (29.73235 - 1.06774) \times 30.03386 : (29.73235 + 20.679233) : : 17.0776 : 1 \tag{11}$$

$$m_0 : m_8 : : (331668 \div 17.0776 = 19392) : 1 \tag{12}$$

$$m_7 : m_3 : : (\beta_7 - \varepsilon_3)\,\gamma_7 : (\beta_7 + \delta_5)\,\gamma_3 : : (20.04418 - .93226) \times 19.18358 : (20.04418 + 4.97824) : : 14.6523 : 1 \tag{13}$$

$$m_0 : m_7 : : (331668 \div 14.6523 = 22602) : 1 \tag{14}$$

The accordance between the nodal and the computed values is shown in the following table :

		Nodal.	Computed.	Authority.
(2)	$m_0 \div m_5$	1047.879	1047.879	Bessel.
(4)	$m_0 \div m_3$	331668.	331776.	Chase.
(6)	$m_0 \div m_2$	427630.	427240.	Hill.
(8)	$m_0 \div m_6$	3503.23	3501.6	Bessel.
(10)	$m_0 \div m_4$	3101613.	3093500.	Hall.
(12)	$m_0 \div m_8$	19393.	19380.	Newcomb.
(14)	$m_0 \div m_7$	22603.	22600.	Newcomb.

The mean orbital *vis viva* which could be communicated to a subsiding particle in any given time, varies directly as the mean gravitating acceleration, $\left(\frac{1}{\gamma}\right)^2$, and inversely as the mean subsidence potential, $\left(\frac{1}{\beta}\right)$. The synchronism in the determination of the *vis viva* of the two chief planets is shown by the proportion

$$m_5 \gamma_6 : m_6 \gamma_5 : : \gamma_6^2 \beta_6 : \gamma_5^2 \beta_5 \qquad (15)$$

which is readily deduced from (7). The confirmation which this lends to Herschel's interpretation of the nebular hypothesis is very satisfactory,

The planets of the dense belt bear witness to an interesting combination of harmonic influences. The simple attraction of a principal centre of condensation would tend to produce radial oscillations and very elliptical orbital paths. If the central force could be concentrated in a point, the elliptic path would coincide with the major-axis and be rectilinear, its orbital time being $2\pi\sqrt{\frac{r}{g}}$ and the mean velocity being $\frac{2}{\pi}\sqrt{gr}$; g representing the acceleration of the central force at the distance r. If the radial oscillations are made circular, (through the mutual collision of particles, the exchange of molecular *vis viva* for *vis viva* of rotation or of revolution, external attraction and other physical disturbances), the orbital velocity should be some function of the nascent velocity, $\frac{gt}{2}$

The combined orbital *vis viva* of Earth and Jupiter, (1), suggests the consideration of nebular subsidence from Moon's apogee towards the mean centre of gravity of Jupiter and Sun. In expanding or contracting nebulæ, rotating velocity and circular orbital *vis viva* both vary inversely as radius. In considering ultimate particles or chemical atoms of equal volume, the mass and the limiting or maximum acceleration both vary as the density ; the limit of gravitating *vis viva*, therefore, varies as the cube of the density, ($\delta \times \delta^2 = \delta^3$) and centrifugal *vis viva* varies as $\frac{1}{\delta^3}$. Circular orbital or tangential atomic *vis viva* varies directly as density and

inversely as radius vector, ($\delta \div \rho$). Equating these two expressions for centrifugal energy, at the centre of condensation, we get

$$\frac{1}{\delta^2} \propto \frac{\delta}{\rho} \qquad (16)$$

$$\delta \propto \rho^{\frac{1}{3}} \propto \frac{t}{\rho^{3}} \qquad (17)$$

$$t^2 \propto \rho^{4} \propto \delta^{12} \qquad (18)$$

The limit of circular orbital time, $2\pi \sqrt{\frac{r}{g}}$, for Earth, is $t_3 = 5073.6$ seconds. Earth's orbital time being $t_1 = 1$ year $= 31558149$ seconds. If these times were fixed by the above relations of "subsidence" we should have

$$31558149^2 : 5073.6^2 :: \delta_a^{12} : \delta_n^{12} \qquad (19)$$

$$\delta_a = 3.8341\ \delta_n \qquad (20)$$

$$\rho_a : \rho_n :: \delta_a^4 : \delta_n^4 :: 216.0944 : 1 \qquad (21)$$

Earth's present density, as deduced from the combined influences of subsidence, linear oscillation, conical oscillation and orbital velocity, (Notes 5, 23), is 3.9231 δ_n, as is shown by the following calculations :

$$m_n = (2 \times 3 \times 4)^4\, m_3 = 331776\, m_3 \qquad (22)$$

$$r_3 = (m_n : m_3)^{\frac{1}{3}} \times (t_1 : t_3)^{\frac{2}{3}} \times r_3 = 92,785,700 \text{ miles.} \qquad (23)$$

$$\rho_n = \rho_3 \div 214.4472^* = 432673.8 \text{ miles.} \qquad (24)$$

$$\left.\begin{array}{l} \delta_3 : \delta_n :: m_3 \div r_3^3 : m_n \div \rho_n^3 :: 3.9231 : 1 \\ \text{or, from (20), (21) and (22), } \delta_3 : \delta_a :: 216.0944^3 : 214.4472^3 \\ \qquad = 3.9231 : 3.8341 \\ \delta_3 : \delta_n = 3.9231 : 1 \end{array}\right\} \qquad (25)$$

In (21) the radius of early lunar telluric subsidence, ρ_a, includes:— α. Moon's orbital radius of incipient subsidence, or locus of apogee, .5824 ρ_a; β. Earth's semi-axis major, 214.4472 ρ_n, (24); and γ. The semi-axis major of the centre of gravity of Sun and Jupiter, 1.0047 ρ_a.

α. According to Von Littrow, Moon's locus of apogee $= 1.054908 \times 60.2776 \times 3962.8 = 251,985$ miles $= .5824\ \rho_n$, (24).

γ. According to Stockwell, (Smithsonian Contrib., 232, p. 38), Jupiter's maximum eccentricity is .0608274. This gives, for the semi-axis major of the chief centre of gravity of the solar system, (Note 113), $\rho_a \div .9391826 = 1.004767\ \rho_n$.

The influence of nascent *vis viva*, at the centre of the belt of greatest condensation, is further shown by the relations which are maintained, with close approximation, between Earth and its adjacent planets.

Nascent velocity at Laplace's limit, and consequent orbital *vis viva*, is

* See Note 113.

π times as great as velocity of rotation at the same limit. This leaves $\pi - 1$ units of Earth's subsident rotating velocity to be converted into orbital *vis viva*. Taking Earth's mass and semi-axis major as the units of mass and distance, the foregoing relative theoretical values of nodal mass yield the following comparative results :—

$$
\left.
\begin{array}{llr|lr}
 & \text{Orbital } \textit{Vis Viva} = \text{Mass} \div \text{Rad. Vect.} & & \text{Theoretical } \textit{Vis Viva}. & \\
\text{Earth} & \qquad\qquad\qquad 1 \div 1 & = 1. & & 1. \\
\text{Venus} & (331668 \div \;\; 427630) \div \;\; .72333 & = 1.0723 & (\pi - 1) \div 2 = & 1.0708 \\
\text{Mars} & (331668 \div 3101613) \div 1.52369 & = \;\; .0702 & (\pi - 3) \div 2 = & .0708 \\
 & & 2.1425 & \pi - 1 & 2.1416
\end{array}
\right\} \quad (26)
$$

The influences of *vis viva* which are represented by the two outer planets, (11) (13), are somewhat more intricate, but no less interesting than those of their companions. Orbital velocity, in the path of any given planet, varies inversely as radius vector, following the same law as variations of rotating velocity in an expanding or contracting nebula, and as variations of orbital *vis viva* in revolving particles at different distances from a controlling centre. Hence there are tendencies to maximum and mean accelerations and retardations at secular and mean apsides, which are shown in the amounts of nodal planetary aggregation that are required to maintain the cyclical equilibrium of orbital *vis viva*. The ratio of Neptune's *vis viva* to the mass at the chief centre of condensation, Earth, is determined by cardinal nodes of Neptune, Uranus and Earth ; the like ratio of the *vis viva* of Uranus, by cardinal nodes of Uranus, Jupiter and Earth. Earth's nodes are those of incipient subsidence and rupture at the centre of density, secular aphelion and perihelion ; the node of Uranus which is influential upon Neptune is that of incipient subsidence ; the three other nodes are of mean subsidence or rupture. Earth's secular aphelion has modified the aphelion planet, while its secular perihelion has modified the perihelion planet of the outer two-planet belt.

Atomic phyllotaxy, times and acquired velocities of subsidence, orbital velocities resulting from subsident *vis viva*, and the relations of density to distance from a controlling centre in an elastic medium, are all illustrated by the *exact* equality, (21) (23):—

$$(t_1 \div t_3)^{1\frac{2}{3}} = \rho_a \div \rho_e \qquad (27)$$

The order of importance of the equilibrating manifestations of cosmical *vis viva* in the solar system, seems to be the following :—

1. The relation of Sun's mass to mass at principal centre of density, Earth, which satisfies necessary tendencies to subsidence, oscillation, and orbital revolution (22).

2. The combined orbital *vis viva* at the chief centre of density and at the centre of primitive nebulosity (1).

3. The incipient tendency to rupture, between the chief centres of nucleation and of nebulosity, Sun and Jupiter (2).

4. The relations of *vis viva* between the chief centres of density and of nebulosity, Earth and Jupiter (3).

5. The relations between mean tendencies to belt-rupture and to secular stability, between the chief centres of nebulosity and of planetary inertia, Jupiter and Saturn, in the chief belt of planetary aggregation (7).

6. The tendency of incipient subsidence towards the chief centre of nucleation, and of incipient rupture from the chief centre of density, Venus, Sun and Earth (5).

7. The tendency of incipient subsidence at the chief centre of density, together with mean tendencies of subsidence at the chief centre of planetary inertia, Earth, Saturn and Mars (9).

8. The combination of incipient tendencies of subsidence at the chief centre of density and at the inner margin of the outer planetary belt, with mean rupturing tendencies at the outer margin of the outer belt (11).

9. The combination of incipient tendencies of rupture at the chief centre of density, with mean rupturing tendencies at the chief centre of nebulosity and mean subsidence at the inner margin of the outer belt (13).

Mercury, with its great orbital eccentricity, the asteroids, comets and meteors, doubtless serve to complete the exact adjustment which the stability of the system requires.

157. *Relations of Fraunhofer Lines to Density and Vis Viva.*

Astronomers do not waste their time in inquiring whether planetary motions are in accordance with the laws of gravitation, neither need physicists ask whether cyclical undulations are harmonic. Knowing that they must be so, the wiser way is to question nature in order to find what the harmonies are. The simplest harmonies are those which are based on multiples of 2 or 3. If we take $\lambda = 392.78$ as a unit, we find the following approximation of wave-lengths, as measured by Gibbs, to harmonic values :

Harmonic.			Observed.	Error.	Probable Error.
$\frac{7}{4}\lambda$		$= 687.37$	B 686.71	$+0.66$	± 24.54
	$\frac{5}{3}\lambda$	$= 654.63$	C 656.21	-1.58	± 32.73
$\frac{6}{4}\lambda$		$= 589.17$	D_1 589.51	-0.34	± 24.54
	$\frac{4}{3}\lambda$	$= 523.71$	E 526.87	-3.16	± 32.73
$\frac{5}{4}\lambda$		$= 490.97$	F 486.07	$+4.90$	± 24.54
$\frac{4}{4}\lambda$	$\frac{3}{3}\lambda$	$= 392.78$	H_2 393.30	-0.52	± 32.73

The probable error, in each instance, is one-fourth of the harmonic divisor, in accordance with Schuster's proposed test. The greatest discrepancy, F, is only $\frac{1}{5}$ of the probable error, or only $\frac{1}{5}$ as great as we might look for without invalidating the evidence of harmonic influence. Such accordance is surely satisfactory enough to encourage further examination.

If we take $l = \frac{1}{24}\lambda$ as a unit, so as to provide for the requirements of centripetal, linear and conical oscillation, ($2 \times 3 \times 4$; see Notes 5, 23, 156), we find the following approximations :—

Harmonic.	Observed.	Error.
$46\,l = 752.83$	A 760.40	—7.57
$44\,l = 720.10$	a 718.47	+1.63
$42\,l = 687.37$	B 686.71	+0.66
$40\,l = 654.63$	C 656.21	—1.58
$36\,l = 589.17$	D_1 589.51	—0.34
$32\,l = 523.71$	E 526.87	—3.16
$30\,l = 490.97$	F 486.07	+4.90
$26\,l = 425.51$	G 430.73	—5.22
$25\,l = 409.15$	h 410.12	—0.97
$24\,l = 392.78$	H_2 393.30	—0.52

If the Fraunhofer lines are, like musical beats, due to the interference of waves which are very nearly but not exactly in unison, their proper investigation requires a consideration of more intricate harmonics than those which are based upon simple binary or ternary division. The harmonic A line seems to be attracted towards the simple octave of H_2, and H_1 indicates a reaction resulting from such attraction. For, if H_1 be divided into 12 parts, (3×4), and H_2 into 15 parts, (3×5), each of the submultiples will also be a submultiple of A, very nearly, if not exactly.

Harmonic.	Observed.	Error.	
$A_0 = 760.38$	A 760.40	+.02	(1)
$\chi_1 = 396.72$	H_1 396.81	—.09	
$\chi_2 = 393.30$	H_2 393.30	.00	

$\chi_1 = \frac{12}{23} A_0$; $\chi_2 = \frac{15}{29} A_0$.

The line b_1 is very nearly $\frac{3}{4}$, or more nearly $\frac{23}{30}$ of H_1; the lines b_4, E, D_1, are very nearly [illegible] (or about $\frac{4}{5}$), [illegible] (or about $\frac{3}{4}$), and $\frac{2}{3}$ of H_2, respectively. In other words, H_1, b_1, A are nearly enough in the simple harmonic ratio 3, 4, 6, to produce luminous beats, or dark lines, while H_2, b_4, E, D_1, A, show a like approximation to 12, 15, 16, 18, 24.

The tendency of the harmonic ratios to become simply geometric, (Notes 41–48), is illustrated by approximations to the following equations: $B = \sqrt{a\,C}$; $D_1 = \sqrt{a\,F}$; $D_2 = \sqrt{C\,E}$; $b_1 = \sqrt{C\,h}$; $b_2 = \sqrt{b_1\,b_4}$; $H_1 = \sqrt{h\,H_2}$. The first of these equations gives the following accordances:

Harmonic.	Observed.	Error.	
$\alpha = 718.51$	a 718.47	+.04	(2)
$\beta = \sqrt{\alpha\,\gamma} = 686.67$	B 686.71	—.04	
$\gamma = 656.25$	C 656.21	+.04	

From (1) and (2) the harmonic series in the following table is constructed by using the exact harmonic ratios $\frac{2}{3}$, $\frac{3}{5}$, $\frac{5}{8}$, $\frac{6}{8}$, $\frac{6}{7}$, together with the disturbing ratios [illegible], [illegible], [illegible], (which are all near enough to $\frac{3}{4}$ to produce luminous beats), and [illegible] which is nearly equivalent to $\frac{3}{8}$. Four of the numbers which appear as terms of the exact harmonic ratios, (2, 3, 5, 8), belong to the phyllotactic series; one, $(6 = 2 \times 3)$, is the product of two adjacent phyllotactic factors; one, 7, is a prime number.

Harmonic		Observed		Error.
A_0	760.38	A	760.40	—.02
a	718.51	a	718.47	+.04
β	686.67	B	686.71	—.04
γ	656.25	C	656.21	+.04
δ	589.95	D_1	589.51	+.44
δ_1	588.57	D_2	588.91	-.34
ϵ	526.74	E	526.87	—.13
β_1	518.16	b_1	518.31	-.15
β_2	517.33	b_2	517.22	+.11
β_4	516.21	b_4	516.69	-.48
φ	486.11	F	486.07	+.04
ζ	431.11	G	430.73	+.38
η	410.16	h	410.12	+.04
χ_1	396.72	H_1	396.81	-.09
χ_2	393.30	H_2	393.30	.00

In the harmonic column, β_1 = [illegible] χ_1 ; β_4, ϵ and δ_1, are obtained by multiplying χ_2 by [illegible], [illegible] and [illegible], respectively : ζ = [illegible] a, and β_2 = [illegible] ζ ; η = [illegible] γ and φ = [illegible] η ; δ_1 = [illegible] β. All the differences between the harmonic and the observed values are unquestionably within the limits of probable errors of observation, as indicated by the different relative estimates of lines in metallic spectra by different observers.

The influence of relative *vis viva* between the chief centres of density and of nucleation, Earth and Sun, is shown both by the spectrum and by the mean rupturing loci of the principal planetary masses, Jupiter and Saturn. Such influence is a necessary consequence of the equality of action and reaction in the interchanges of ethereal, molecular and cosmical *vis viva*. The sum, or the mean of all the gravitating accelerations upon the ethereal particles in a radius vector by each of two mutually attracting bodies, is proportioned to their respective masses, $g \propto m$. The resulting mean *vis viva* of subsidence, mg^2, is proportioned to the cubes of the masses. Nascent *vis viva* is $\pi^2 \times$ orbital *vis viva*, or $\pi^2 \times$ representative orbital projection against uniform ethereal resistance, or $2\pi \times$ the corresponding nascent projection. If we take the theoretical oscillatory ratio between the masses at the chief centres of density and nucleation, m_n = 331776 m_3 : ρ_3 = 92785700 miles = 149320000000 metres. Hence the proportions :

$$149320000000 : 331776^3 :: \pi^2 : .0000000041432$$

$$149320000000 : 331776^3 :: 2\pi : .0000000065073$$

Both of these values represent spectral wave lengths, one being about one per cent. greater than h, the other about $\frac{3}{4}$ of one per cent less than C. The ratio between the values, $\frac{\pi}{2}$, is to the ratio of C to h, [illegible], as Sun's semi-diameter, 1, is to the mean rupturing radius vector of the centre of gravity of Sun and Jupiter, 1.01859. The projectile ratio of 414.32 from h, .01014, is to the projectile ratio of C from 650.73, .00848, as Jupiter's mean projection from Sun, 5.203, is to Saturn's mean projection from Jupiter, 4.336, within $\frac{1}{4}$ of one cent.

The Names of the Gods in the Kiche Myths, Central America. *By Daniel G. Brinton, M.D.*

(Read before the American Philosophical Society, November 4, 1881.)

CONTENTS.

Of the ancient races of America, those which approached the nearest to a civilized condition spoke related dialects of a tongue, which from its principal members has been called the "Maya-Kiche" linguistic stock. Even to-day, it is estimated that about half a million persons use these dialects. They are scattered over Yucatan, Guatemala and the adjacent territory, and one branch formerly occupied the hot lowlands on the Gulf of Mexico, north of Vera Cruz.

Of the sixteen different dialects into which this stock has been divided, the Maya was considered by that eminent authority, the late Dr. C. H. Berendt, to be the purest example ; although it has also been asserted that the most archaic forms and structure are to be found in the Zakloh-Pakab, otherwise called the Mam, spoken in a portion of the province of Soconusco and Chiapas, by a tribe which alone of these natives, so far as I know, claimed to be autochthonous. The Mam is agglutinative, and its grammatical structure is complex, traits much less marked in the other members of the group.

The so-called "metropolitan" dialects are those spoken relatively near the city of Guatemala, and include the Cakchiquel, the Kiche, the Pokonchi and the Tzutuhil. They are quite closely allied, and are mutually intelligible, resembling each other about as much as did in ancient Greece the Attic, Ionic and Doric dialects. These closely related members of the Maya-Kiche family will be referred to under the sub-title of the Kiche-Cakchiquel dialects.

There are well defined phonetic laws which have governed the growth of all these dialects, and several of them have been clearly set forth by M. Hyacinthe de Charencey in a comparative study published some years ago.* In regard to their phonetic system, it may be said that it is charac-

* *Recherches sur les Lois Phonétiques dans les Idiomes de la Famille Mame-Huastèque.* Revue de Linguistique, Tome v.

terized by numerous harsh gutturals, by hissing sounds, and explosive or "detonating" consonants, which strike most European ears disagreeably, and in the alphabetic representation of which there is no uniformity among authors.*

The civilization of these people was such that they used various mnemonic signs, approaching our alphabet, to record and recall their mythology and history. Fragments, more or less complete, of these traditions have been preserved. The most notable of these is the National Legend of the Kiches of Guatemala, the so called *Popol Vuh*. It was written at an unknown date in the Kiche dialect by a native who was familiar with the ancient records. A Spanish translation of it was made early in the last century by a Spanish priest, Father Francisco Ximenez, and was first published at Vienna, 1857.† In 1861 the original text was printed in Paris, with a French translation, by the care of the late eminent Americanist, the Abbé Brasseur (de Bourbourg). This original covers about 175 octavo pages, and is therefore highly important as a linguistic as well as an archæological monument.

Both these translations are justly open to criticism. It needs but little study to see that they are both strongly colored by the view which the respective translators entertained of the purpose of the original. Ximenez thought it was principally a satire of the devil on Christianity, and a snare spread by him to entrap souls; Brasseur believed it to be a history of the ancient wars of the Kiches, and frequently carries his Euhemerism so far as to distort the sense of the original.

What has added to the difficulty of correcting these erroneous impressions is the extreme paucity of material for studying the Kiche. A grammar written by Ximenez has indeed been published, but no dictionary is available, if we except a brief "Vocabulary of the Principal Roots" of these dialects by the same author, which is almost useless for critical purposes.

It is not surprising, therefore, that some writers have regarded this legend with suspicion, and have spoken of it as but little better than a late romance concocted by a shrewd native, who borrowed many of his incidents from Christian teachings. Such an opinion will pass away when

* After some hesitation I have adopted the orthography *Kiche* instead of the more usual *Quiche*. The initial letter is in fact neither *k* nor *q*, but a rough guttural represented by a peculiar letter in the manuscripts, and for the sound of which we have nothing to correspond in European alphabets. Dr. Berendt transliterated the name as *Ki'che*; and apart from its being on the whole more correct, it prevents confusion with the Quichua of Peru. *Kiche* is a compound of *ky* or *ki*, much, many, and *che* trees. The orthography adopted by Mr. A. F. Bandelier, and credited by him to Dr. Berendt, to wit, *QQuiche* (*Twelfth Annual Report of the Peabody Museum*, p. 63, note) was not used by Dr. Berendt, and should not be adopted, as it is without authority, and increases the liability of confusion with the Peruvian language.

† *Las Historias del Origen de los Indios de esta Provincia de Guatemala.* Por el R. P. F. Francisco Ximenez.

the original is accurately translated. To one familiar with native American myths, this one bears undeniable marks of its aboriginal origin. Its frequent puerilities and inanities, its generally low and coarse range of thought and expression, its occasional loftiness of both, its strange metaphors, and the prominence of strictly heathen names and potencies, bring it into unmistakable relationship to the true native myth. This especially holds good of the first two-thirds of it which are entirely mythological.

As a contribution to the study of this interesting monument, I shall undertake to analyze the proper names of the divinities which appear in its pages. The especial facility that I have for doing so is furnished by two MSS. Vocabularies of the Cakchiquel dialect, presented to the library of the American Philosophical Society by the Governor of Guatemala in 1836. One of these was written in 1651, by Father Thomas Coto, and was based on the previous work of Father Francisco Varea. It is Spanish-Cakchiquel only, and the final pages, together with a grammar and an essay on the native Calendar, promised in the body of the work, are unfortunately missing. What remains, however, makes a folio volume of 972 double columned pages, and contains a mass of information about the language. As no part of it has ever been published, I shall quote freely from it. The second MSS. is a copy of the Cakchiquel-Spanish Vocabulary of Varea made by Fray Francisco Ceron in 1699. It is a quarto of 493 pages. I have also in my possession copies of the *Compendio de Nombres en Lengua Cakchiquel*, by P. F. Pantaleon de Guzman (1704), and of the *Arte y Vocabulario de la Lengua Cakchiquel*, by the R. P. F. Benito de Villacañas, composed about 1580, as well as a copy of the *Memorial de Tecpan-Atitlan*, an important record written about the middle of the 16th century by a member of the royal Cakchiquel house of the Xahila. These formed part of the invaluable collection left by the late Dr. C. Hermann Berendt, and have aided me in my researches.

Father Coto himself tells us that the natives loved to tell long stories, and to repeat chants, keeping time to them in their dances. These chants were called *nugum tzih*, garlands of words, from *tzih*, word, and *nug*, to fasten flowers into wreaths, to set in order a dance, to arrange the heads of a discourse, etc. As preserved to us in the Popol Vuh, the rhythmical form is mostly lost, but here and there one finds passages, retained intact by memory no doubt, where a distinct balance in diction, and an effort at harmony is readily noted.

The name *Popol Vuh* given to this work is that applied by the natives themselves. It is translated by Ximenez "libro del comun," by Brasseur "livre national." The word *popol* is applied to something held in common ownership by a number; thus food belonging to a number is *popol naim;* a task to be worked out by many, *popol samah;* the native council where the elders met to discuss public affairs was *popol tzih*, the common speech or talk. The word *pop* means the mat or rug of woven rushes or bark on which the family or company sat, and it is possible that

from the community of interests thus typified, the word came to mean anything in common.*

Vuh or *uuh* is in Kiche and Cakchiquel the word for *paper* and *book*. It is an original term in these and connected dialects, the Maya having *uooh*, a letter, writing; *uoch*, to write.

The opening words of the Popol Vuh introduce us at once to the mighty and mysterious divinity who is the source and cause of all things, and to the original couple, male and female, who in their persons and their powers typify the sexual and reproductive principle of organic life. These words are as follows:

"We are to bring forward the manifestation, the revelation, "the declaration of that which was hidden, the enlightenment "caused by Him who Creates, Him who fashions creatures, "Her who bears sons, Him who begets sons, whose names are "Hun Ahpu-Vuch, Hun-Ahpu-Utiu, Zaki-Nima-Tzyiz, Tepeu, "Gucumatz, Qux cho, Qux palo, Ah-raxa-lak, Ah-raxa-sel.

"And along with Him are sung and celebrated in the Kiche "histories, those who are called the ancestress and the ances-"tor, by name Xpiyacoc, Xmucane, the preserver, the protec-"tor; twice over grandmother, twice over grandfather."

It will be here observed that the declaration of the attributes of the highest divinity embraces distinctly sexual ideas, and in consequence either of a confusion of thought or else of a deliberate purpose to which we find numerous parallels in Grecian, Egyptian and Oriental mythology, this divinity is represented as embracing the powers and functions of both sexes in his own person; and it is curious that both here and in the second paragraph, the *female* attributes are named *first*.

The word *Alom*, her who bears sons, or has sons (*la muger que tiene hijos*, Coto) is from the verbal form *alah*, to bring forth children, itself from the primitive *al*, the word in all this group of languages applied *by the woman only* to her son. The father used an entirely different word, to wit, *qahol*. The active form of this, *Qaholom* (ꜫ a holom) is that translated, He who begets sons.

First in the specific names of divinity given is *Hun ahpu vuch*. To derive any appropriate signification for this has completely baffled all previous students of this mythology. *Hun* is the numeral *one*, but which also, as in most tongues, has the other meanings of first, foremost, self, unique, most prominent, "the one," etc. *Ahpu* is derived both by Ximenez and Brasseur from the prefix *ah*, which is used to signify knowledge or posses

* The meaning "a gathering of leaves" assigned to the words *popol vuh*, by Mr. A. F. Bandelier in a recent paper (*Transactions of the American Assoc. Ad. Science*, Vol. XXVII, p. 328), I should, perhaps, mention, in order to say that it is quite imaginary and groundless.

sion of, control over, mastership or skill in, origin from or practice in that to which it is prefixed; and *ub*, or *pub*, the *sarbacana* or blowpipe, which these Indians used to employ as a weapon in war and the chase. *Ah pu*, therefore, they take to mean, He who is skilled in using the sarbacane. *Vuch*, the last member of this compound name, is understood by both to mean a species of fox, the *tlacuatzin* of the Mexicans, which is the Opossum.

In accordance with these derivations Ximenez translates the name *Un tirador tacuasin*, and Brasseur, *Un Tireur de Sarbacane au Sarigue*.

Such a name bears little meaning in this relation; little relevancy to the nature and functions of God; and if a more appropriate and not less plausible composition could be suggested, it would have strong intrinsic claims for adoption. There is such a composition, and it is this: The derivation of Ahpu from *ah-pub* is not only unnecessary but hardly defensible. It is true that in Cakchiquel the sarbacane is *pub*, but in Kiche the initial *p* is dropped, as can be seen in many passages of the Popol Vuh, but, this apart, the true composition of this word I take to be unquestionably *ah-puz*, for *puz* has a distinctly relative signification, one intimately associated with the most recondite mysteries of religion; it expressed the divine power which the priests and prophets claimed to have received from the gods, and the essentially supernatural attributes of divinity itself. It was the word which at first the natives applied to the power of the forgiving of sins claimed by the Catholic missionaries; but the word was associated with so many wholly heathen notions that the *padres* decided to drop it altogether from religious language, and to give it the meaning of necromancy and unholy power. Thus Coto gives it as the Cakchiquel word for *Magica*, *Nigromantica*, and under the word *Poder*, has this interesting entry:

"**Poder:** *vtziniçabal*, vel *vtzintaçibal;* deste nombre usa la *Cartilla* en el "Credo para decir por obra vel poder del Spirito Santo. Al poder que "tienen los Sacerdotes de perdonar pecados y dar sacramentos, se "llaman, o an llamado, *puz, naual.* Asi el Pe Varea en su *Diccionario* "y el Sancto Vico en la *Theologia Indorum* usa en muchas partes destos "vocablos en este sentido. Ya no estan tan en uso, pues entienden por "el nombre *poder* y *vtzintaçibal;* y son vocablos que antiguamente aplica-"ban a sus idolos, y oy se procura que vayan olbidando todo aquello "con que se les puede hacer memoria dellos."

The word *puz* is used in various passages of the Popol Vuh to express the supernatural power of the gods and priests, but probably by the time that Ximenez wrote it had, in the current dialect of his parish, lost its highest signification, and hence it did not suggest itself to him as the true derivation of the name I am discussing.

The third term *Vuch* or *Vugh* was chosen according to Ximenez, because this species of fox is notoriously cunning, "*por su astucia.*" It seems to me on the whole probable that this is correct, and that we have here a reminiscence of an animal myth, such as we might suppose in an early stage of civilization might have grown out of the story of Reynard

the Fox. It is certain that cunning and astuteness in small things are traits of character exceedingly admired by the vulgar and uneducated everywhere, and it is quite possible that they came to be looked upon as appropriate attributes of the highest conceivable divinity, as, indeed, there is no doubt but that they were among the Algonkin and other hunting tribes of the North.

But while, as I say, I am inclined to accept the rendering of *Vuch* as the tlacuatzin, it has not this meaning only, but several others, some of which are so suggestive that I shall quote what Father Coto has to say on the subject under the word *Raposo*, so that the reader may adopt another meaning if he chooses.

"**Raposo**: *xicou*; estos son los mas paresciclos a los de España. * * *;
"otro genero que como gallinas, el Mexicano le llama tacuatçin; a este
"llaman *Vuch*; y nota que este mesmo nombre tiene un genero de baile
"en que con los pies dan bueltas a un palo, tambien significa el temblor
"de cuerpo que da con la terciana, o la misma çession; significa asi
"mesmo quando quiere ya amanescer aquel ponerse escuro el cielo,
"tambien quando suele estar el agua del rio o laguna, por antiparestas-
"sis, caliente, al tal calorsillo llaman *Vuch*."

Of these various meanings one is tempted to take that which applies the word to "the darkness that comes before the dawn," and connect Hun ahpu vuch with the auroral gods, the forerunners of the light, like the "Kichigouai, those who make the day," of Algonkin mythology.

There is a curious passage in the Popol Vuh which might be brought up in support of such an opinion. It occurs at a certain period of the history of the mythical hero Hunahpu. The text reads:

"Are cut ta chi r'ah saktrie,	"And now it was about to become white,
"Chi zaktarin,	And the dawn came,
"U xecah ca xaquinuchie,	The day opened,
"Ama x-u ch'ux ri vuch?	'Is the fox about to be?'
"Ve, x-cha ri mama,	Yes, answered the old man.
"Ta chi xaquinie;	Then he spread apart his legs;
"Qate ta chi gekumar chic;	Again the darkness appeared;
"Cahmul xaquin ri mama.	Four times the old man spread his legs
"Ca xaquin-Vuch," ca cha vinak vacamic.	"Now the Fox spread his legs," say the people yet (meaning that the day approaches).

This passage, says the Abbé Brasseur in his note to the page, "conceals a mystery having relation to the ancient genesiac theories of Mexico and Central America."

The double meaning in this text depends partly on the verb *xaquinuchie*. The Abbé says: "*Xaquin* signifie ouvrir les jambes, et *uch* ou *vuch* est le sarigue. Pour exprimer que le jour parut, on dit textuellement, le sarigue entr'ouvre les jambes" This word is from the same root as the Maya *Xech*, to spread the feet apart, *xecnah*, to spread the legs (Pio Perez, *Diccionario*): Cakchiquel, *tin xecaba ca*, I spread my legs (*Je abre*

las piernas, Coto, *Vocabulario*.) A modification of the root, to wit, *q'aq*, means to open, generally, a door, window, etc.

The Abbé adds that the expression referred to by the writer of the Popol Vuh as a common one to express the approach of day is no longer in use ; but it had not become obsolete in Coto's time, as the following passage shows :

"**Escuridad :** una que ay quando quiere amanescer, *vugh ; tan ti zakin "vugh*."

Here we have the precise expression under consideration, and as it is also given by Guzman (*Compendio de Nombres*, p. 22) it is probably an error of Brasseur's to consider it obsolete.

So long, however, as there is no further evidence to support the identity of Hun-ahpu-vuch with the dawn-heroes, we may reasonably explain this supposed genesiac myth as based on the homophony of *vuch*, fox, and *vuch*, the darkening before dawn. This homophony contains, indeed, rich material for the development of an animal myth, identifying the fox with the God of Light, just as the similarity of the Algonkin *waubisch*, the dawn, and *waubos*, the rabbit, gave occasion to a whole cycle of curious myths in which the Great Hare or the Mighty Rabbit figures as the Creator of the World, the Day Maker, and the chief God of the widely spread Algonkin tribes.*

The result of the above analysis is to assign Hun-ahpu-vuch the signification : "The One (or chief) master of supernatural power, the Opossum."

A main reason why I retain the meaning Opossum is that the names which follow are unquestionably derived from animals. The second is *Hun-Ahpu-Utiu*. The last factor, *utiu* is the wolf, the coyote, an animal which plays most important parts in the native cosmogonical myths all through the Californian, Mexican and Central American tribes. In the *Records from Tecpan Atitlan* it is related that when man was first formed by the power of the sacred Chay Abah, the knife-stone or obsidian, and placed in the earthly paradise Paxil (the derivation of which name I shall consider later) there came the coyote, *utiu*, and the crow, *kooch*, and were about to destroy the maize harvests, but the coyote was killed, and thus the grain was saved. The remaining elements being the same I paraphrase this :

"The One (or chief) master of supernatural power, the Coyote."

In the third name, *Zaki Nima Tzyiz*, the first two words mean respectively *White, great ;* the third is the common name for the pizote or badger, an active little animal quite familiar to the Indians, and the name of which, as we are informed by Father Coto, was currently applied to an active, lively lad. His words are :

"**Pizote :** vn animalejo como el tejon, o el mesmo, *çiz* ; son caserositos,

* I have traced the growth of this myth in detail in *The Myths of the New World, a Treatise on the Symbolism and Mythology of the Red Race of America*, Chap. VI. (New York, 1876).

"cogen pequenos, y trauiesos mucho, y de aqueste animal toman el decir "quando vn muchacho es travieso, *çizulah aqual,* etc."

These are the translations given by Ximenez: "grandemente agudo pizote," "very active pizote," and "blanco pizote," "white pizote." But Brasseur derives *tzyiz* from *tzizo,* to sew, and, in a religious sense, to draw blood by pricking, a sacrificial custom of those countries, for which he adduces the authority of the MSS. Kiche vocabulary of Basseta; "Sangrarse para sacrificar á los idolos." He therefore translates: "Grand Blanc Piqueur;" but this seems inadmissible, as "the one who sews or pricks" is expressed by *tzizom* or *tzizonel* (*Coto,* s. v. *Coser*). We must therefore include this among the animal names.

Although not contained in the paragraph quoted, I here bring under consideration another animal name which elsewhere in the Popol Vuh is used as synonymous with the above. Thus (p. 20) we have this invocation:

"Make known your name, Hun-ahpu-vuch, Hun-ahpu-utiu,
"twice over bearer of children, twice over begetter of children,
"Nim-ak, Nim-tzyiz, master of the emerald," etc.

The name *Nim-ak* is elsewhere given *Zaki-nim-ak.* The former means "Great Hog," the latter "White, Great Hog." Brasseur translates *ak* as wild boar (*sanglier*), but it is the common generic name for the hog, without distinction of sex. In a later passage (p. 40), we are informed that it was the name of an old man with white hair, and that Zaki-nima-tzyiz was the name of an old woman, his wife, all bent and doubled up with age, but both beings of marvelous magic power. Thus we find here an almost unique example of the deification of the hog; for once, this useful animal, generally despised in mythology and anathematized in religion, is given the highest pedestal in the Pantheon.

We should probably understand these and similar brute gods to be relics of a primitive form of totemic worship, such as was found in vigor among some of the northern tribes. Various other indications of this can be discovered among the branches of the Maya family. The Cakchiquels were called "the people of the bat" (*zoq'*), that animal being their national sign or token, and also the symbol of their god (*Popol Vuh,* p. 225, 249). The *tucur* owl, *chan* or *cumatz* serpent, *balam* tiger, and *geh* deer, are other animals whose names are applied to prominent families or tribes in these nearly related myths.

The priests and rulers also assumed frequently the names of animals, and some pretended to be able to transform themselves into them at will. Thus it is said of Gucumatz Cotuha, fifth king of the Kiches, that he transformed himself into an eagle, into a tiger, into a serpent, and into coagulated blood (p. 314). In their dances and other sacred ceremonies they used hideous masks, carved, painted and ornamented to represent the heads of eagles, tigers, etc. These were called *goh,* as *cohbal ruvi cot,*

the mask of an eagle, *cohbal ruri balam;* the mask of a tiger, etc. (Coto, s. v. *Mascara* vel *Caratula.*) In Maya the same word is found, *Koh*, and in the Codex Troano, one of the few original Maya manuscripts we have left, these masks are easily distinguished on the heads of many of the persons represented. Recent observers tell us that in the more remote parishes in Central America these hideous brute faced masks are still worn by the Indians who dance in accompanying the processions of the Church!* Even yet, every new-born child among the Kiches, is solemnly named after some beast by the native "medicine man" before he is baptized by the Padre.†

This brings me to a name which has very curious meanings, to wit, *Tepeu.* It is the ordinary word in these dialects for Lord, Ruler, Chief or King. Its form in Cakchiquel is *Tepex*, in Maya *Tepal*, and it is probably from the adjective root *tep*, filled up, supplied in abundance, satisfied (colmado, satisfecho, que tiene sufficiente, Brasseur, *Vocabulaire Maya-Français et Español*). In Kiche and Cakchiquel it is used synonymously with *galel* or *gagal* and *ahau* as a translation of Señor or Cacique. But it has another definite meaning, and that is, the disease *syphilis, the buboes* or *pox!* And what is not less curious, this meaning extends also in a measure to *galel* and *ahau*.

This extraordinary collocation of ideas did not escape the notice of Ximenez, and he undertakes to explain it by suggesting that as syphilis arises from cohabitation with many different women, and this is a privilege only of the great and powerful, so the name came to be applied to the chiefs and nobles, and to their god. But I shall give this explanation in his own words:

"Y tambien como à Dios se le dan muchos epitetos de grande, de sabio "y otras cosas, le dan el nombre de Tepeu, este significa las bubas, y en "su gentilidad era grandeza de los Señores el tenirlos, porque era señal "de mas poder para cohabitar con muchas mugeres de adonde se suelen "contraer, cosa que la gente ordinaria no podia."‡

Of course, syphilis has no such origin, but if the Indians thought it had, and considered it a proof of extraordinary genetic power, it would be a plausible supposition that they applied this term to their divinity as being the type of the fecundating principle. But the original sense of the adjective *tep* does not seem to bear this out, and it would rather appear that the employment of the word as the name of the disease was a later and secondary sense. Such is the opinion of Father Coto who says that the term was applied jestingly to those suffering from syphilitic sores because, like a chieftain or a noble, they did no work, but had to sit still with their hands in their laps, as it were, waiting to get well; and when they had

* *Die Indianer von Santa Catalina Istlavacan; ein Beitrag zur Culturgeschichte der Urbewohner Central Amerikas.* Von Dr. Karl. Scherzer, p. 9 (Wien. 1856).

†Ibid, p. 11.

‡ *Escolios à las Historias del Origen de los Indios*, pag. 157.

recovered it was satirically said of them that they had given up their sovereignty. To quote his words:

"**Bubas:** *gal* vel *tepex.* * * Quando an pasado dicen *xin colah* "*ah mareem*, id est, ya an dejado su señoria, porque el que las tiene se "esta sentado, sin hacer cosa, como si fuese señor ó señora.

"**Señora:** *xoyohau*; Señoria, *xoyohauarem* * * Deste nombre *xoyo-*"*hau* vsan metaphoricamente para decir que una muger moza tiene "bubas; porque se esta sin hacer cosa, mano sobre mano. * * y "quando a sanado de la enfermedad, dicen, si es varon: *xucolah* "*rahauarem achi rucal tepex.* *Tepex* es la enfermedad de bubas."

I should not omit to remark that this strange association of ideas is not confined to the dialects of which I am speaking. It occurs not unfrequently. In Maya, *ku* is the earliest and broadest name for divinity: *kukul* is to worship, and it also means a scab or sore. As in Kiche *puh* means the pus or matter from a sore, the term *ahpu* applied to the highest god may also mean, "he who has running sores." Furthermore, in the Aztec tongue *nanahuatl* means a person suffering from syphilis; it is also, in a myth preserved by Sahagun, the name of the Sun God, and it is related of him that as a sacrifice, before becoming the sun, he threw into the sacrificial flames, not precious gifts, as the custom was, but the scabs from his sores.* So also Caracaracol, a prominent figure in Haytian mythology is represented as suffering from sores or buboes.

The name *Gucumatz* is correctly stated by Ximenez to be capable of two derivations. The first takes it from *gugum*, a feather; *tin gugumah*, I embroider or cover with feathers (enplumar algo, como ponen en los guaypiles, etc. Coto. S. v. *Pluma*). The second derivation is from *gug*, feather, and *cumatz*, the generic name for serpent. The first of these is that which the writer of the Popol Vuh preferred, as appears from his expression: "They are folded in the feathers (*gug*), the green ones; therefore their name is Gugumatz; very wise indeed are they (p. 6)." The brilliant plumage of the tropical birds was constantly used by these tribes as ornament for their clothing and their idols, and the possession of many of these exquisite feathers was a matter of much pride and pleasure. The

*Boturini gives a moral coloring to this myth, which most likely it did not originally have. His version is that at the time of the Second Age, the gods gathered together all the people to reward them for their virtue, and ordered those who felt themselves meritorious enough to cast themselves into a fire, and thus attain celestial rewards. They began to debate who first should take the leap. While they were thus disputing the god Centeotl-Inopiltzin (esto es el dios huerfano, solo y sin padres) appeared to one who was sick, Nana-huatzin (el bubaso, el podrido) and said: "What do you do here? Do you not see that your companions are engaged in vain disputes? Fling yourself into the flames and thus rid yourself of the sufferings which for years you have borne with heroism, and gain immortal honor." Inspired by these words, Nana-huatzin sprang into the flames, and his companions watched him consume. Then an eagle descended from heaven and carried his ashes to the sky where he became Tonatiuh, the Sun. Boturini Benaducci, *Idea de una Nueva Historia General de la America Septentrional*, pp. 37, 38 (Madrid, 1746).

long green ones especially called *gug* (properly $\overset{c}{\underset{c}{}}u\overset{c}{\underset{c}{}}$) were paid as tribute by the inferior chiefs (Varea, *Vocabulario*, s. v.).

A less likely derivation is from *chu*$\overset{c}{\underset{c}{}}$*a*, strong or strength, and *cumatz*, the Strong Serpent. Probably "decorated with feathers" is the correct interpretation. Gucumatz is said by Mr. H. H. Bancroft to be "the acknowledged representative of Quetzalcoatl," * a hasty statement, as the name is hardly more than a common adjective equivalent to royal or magnificent.

The names *Qux cho, Qux palo,* mean "the Heart of the Lake, the Heart of the Sea." To them may be added *Qux cah,* "the Heart of the Sky," and *Qux uleu,* "the Heart of the Earth," found elsewhere in the Popol Vuh (pp. 8, 12), and applied to divinity. The literal or physical sense of the word heart was, however, not that which was intended; in those dialects this word has a much richer metaphorical meaning than in our tongue; with them it stood for all the psychical powers, the memory, will and reasoning faculties, the life, the spirit, the soul. This is fully set forth by Coto:

"**Corazon,** *gux*. * * Atribuenle todos los affectos de las potencias, "memoria y entendimiento y voluntad, * * unde *ahgux*, el cuida-"doso, entendido, memorioso * *; toman este nombre *gux* por el "alma de la persona, y por el spirito vital de todo viviente, v. g. *xel ru* "*gux Pedro*, murió Pedro, vel, salio el alma de Pedro. * * deste "nombre *gux* se forma el verbo *tin gux lah*, por pensar, cuidar, "imaginar."

It would be more correct therefore, to render these names the "Spirit" or "Soul" of the lake, etc., than the "Heart." They represent broadly the doctrine of "animism" as held by these people, and generally by man in his early stages of religious development. They indicate also a dimly understood sense of the unity of spirit or energy in the different manifestations of organic and inorganic existence.

This was not peculiar to the tribes under consideration. The heart was very generally looked upon, not only as the seat of life, but as the source of the feelings, intellect and passions, the very soul itself.† Hence, in sacrificing victims it was torn out and offered to the god as representing the immaterial part of the individual, that which survived the death of the body.

The last two names in the paragraph quoted are *Ah-raxa-lak, Ah-raxa-sel*. To these Brasseur gives the high sounding renderings, "Master of the verdant Planisphere," "Master of the azure Surface." The literal translation is in laughable contrast to these turgid epithets; strictly speak-

* *Native Races of the Pacific Coast*, Vol. III, p. 477, note.

† "De adonde" remarks Granados y Galvez, "viene que mis Otomites, de una misma manera llaman à la alma que al corazon, aplicandoles à entrambos la voz *muy*." *Tardes Americanas*, Tarde IV, p. 101. (Mexico, 1778.)

ing they signify. "He of the green dish." "He of the green cup." Thus Ximenez gives them, and adds that forms of speech with *rax* signify things of beauty, fit for kings and lords, as are brightly colored cups and dishes.

Rax is the name of the colors blue and green, which it is said by many writers, cannot be distinguished apart by these Indians; or at least that they have no word to express the difference. *Rax*, by extension, says Ximenez (*Gramatica de la Lengua Quiche*, p. 17), means strong, rough, violent, etc. Coming immediately after the names "Soul of the Lake," "Soul of the Sea," it is possible that the "blue plate" is the azure surface of the tropical sea.

In the second paragraph I have quoted the narrator introduces us to "the Ancestress (*iyom*), the ancestor (*mamom*), by name Xpiyacoc, Xmucane." These were prominent figures in Kiche mythology; they were the embodiments of the paternal and maternal powers of organic life; they were invoked elsewhere in the Popol Vuh to favor the germination of seeds (p. 20), and the creation of mankind; they are addressed as "ancestress of the sun, ancestress of the light" (p. 18). The old man, Xpiyacoc, is spoken ot as the master of divination by the *tzite*, or sacred beans (p. 23); the old woman, Xmucane, as she who could forecast days and seasons (*ahgih*); they were the parents of those mighty ones "whose name was Ahpu," masters of magic (p. 69). From this ancient couple, Ximenez tells us the native magicians and medicine men of his day claimed to draw their inspiration, and they were especially consulted touching the birth of infants, in which they were still called upon to assist in spite of the efforts of the padres. It is clear throughout that they represented mainly the peculiar functions of the two sexes.

Their names perhaps belonged to an archaic dialect and the Kiches either could not or would not explain them. Brasseur does not offer any etymology, and all that Ximenez says is that Xmucane means *tomb* or *grave* (entierro o fosa), deriving it from the verb *tin muk*, I bury.

In most or all of the languages of this stock the root *muk* or *muc* means to cover or cover up (*encubrir*). In Maya the passive form of the verbal noun is *muc aan*, of which the *Diccionario de Motul** gives the translation "cosa que esta encubierta ò enterrada," the second meaning arising naturally from the custom of covering the dead body with earth, and indicated that the mortuary rites among them were by means of interment; as, indeed, we are definitely informed by Bishop Landa.† The feminine prefix and the terminal euphonic *e* give precisely *X mucaan-e*, meaning "She who is covered up," or buried.

But while etymologically satisfactory, the appropriateness of this deri-

* The *Diccionario de Motul* is the most complete dictionary of the Maya ever made. It dates from about 1590 and has its name from the town of Motul, Yucatan, where it was written. The author is unknown. Only two copies of it are in existence, one, very carefully made, with numerous notes, by Dr. Berendt, is in my possession. It is a thick 4to of 1500 pages.

† *Relacion de las Cosas de Yucatan*, § XXXIII.

vation is not at once apparent. Can it have reference to the seed covered by the soil, the child buried in the womb, the egg hidden in the nest, etc., and thus typify one of the principles or phases of reproduction? For there is no doubt, but that it is in the category of divinities presiding over reproduction this deity belongs.

Both names may be interpreted with appropriateness to the sphere and functions of their supposed powers, from radicals common to the Maya and Kiche dialects. Xmucane may be composed of the feminine prefix *x* (the same in sound and meaning as the English pronominal adjective *she* in such terms as *she bear, she cat*): and *mukanil*, vigor, force, power, (fortaleça, fuerza, poder, Brasseur, *Vocabulaire Maya, Francais et Español*, on the authority of Ruz and Beltran).

Xpiyacoc is not so easy of solution, but I believe it to be a derivative from the root *xib*, the male, whence *xipbil*, masculinity, and especially the *membrum virile* (Pio Perez, *Diccionario Maya*); and *oc* or *ococ*, to enter, to accouple in the act of generation (entrar, juntarse el macho con la hembra, Brasseur, *Vocabulaire Maya*, s. v. *oc*).*

We can readily see with these meanings hidden in them, the subtler sense of which the natives had probably lost, that they would be difficult of satisfactory explanation to the missionaries, and that they would be left by them as proper names of undetermined origin.

The second fragment of Kiche mythology which I shall analyze is one that relates to the gods of the storm. These are introduced as the three manifestations of Qux-cha, the Soul of the Sky, and collectively "their name is Hurakan:"

"Cakulha Hurakan is the first; Chipi-cakulha is the second; "the third is Raxa-cakulha; and these three are the Soul of "the Sky" (p. 8).

Elsewhere we read:

"Speak therefore our name, honor your mother, your "father; call ye upon Hurakan, Chipi-cakulha, Raxa-cakulha, "Soul of the Earth, Soul of the Sky, Creator, Maker, Her who "brings forth, Him who begets; speak, call upon us, salute "us." (p. 14).

Cakulha (Cakchiquel, *cokolahay*) is the ordinary word for the lightning;

*This Vocabulary collected by the Abbé Brasseur (de Bourbourg) was published in the second volume of the reports of the *Mission Scientifique au Mexique et dans l'Amérique Centrale, Paris*, 1870. I regret to say that like all of his linguistic work, it must be followed with great caution. He has inserted in it many words and forms which are not Maya at all, and the derivations he gives and suggests are generally the merest guesses, based on the slenderest analogies of sound. In fact, a careful student of the tongue should not accept any Maya word on the sole authority of Brasseur's work.

Raxa-cakulha, translated by Brasseur "la foudre qui frappe subitement" is rendered by Coto as "the flash of the lightning" (*el resplandor del rayo*); Chipi-cakulha is stated by Brasseur to mean "le sillonnement de l'eclair;" *ghip* is used to designate the latest, youngest or least of children, fingers, etc.

There remains the name Hurakan and it is confessedly difficult. Brasseur says that no explanation of it can be found in the Kiche or Cakchiquel dictionaries and that it must have been brought from the Antilles where it was the name applied to the terrible tornado of the West Indian latitudes, and, borrowed from the Haytians by the early navigators, has under the forms *ouragan, huracan, hurricane,* passed into European languages. In default of any other probable origin such for a long time was my own opinion, and it is indeed difficult to allow the probability that in Hayti and Guatemala the same word should be applied to the same conception, and this one of such magnitude and impressiveness, and that there should be no historic connection between the two. However that may be, I am now convinced that the word Huracan belongs in its etymology to the Maya group of dialects, and must be analyzed by them.

One such etymology is indeed offered by Ximenez, but an absurd one. He supposed the word was compounded of *hun,* one *ru* his, and *rakan* foot, and translates it "*de un pie.*" This has very properly been rejected.

On collating the proper names in the Popol Vuh there are several of them which are evidently analogical to Hurakan. Thus we have *Cabrakan,* who is represented as the god of the earthquake, he who shakes the solid earth in his might and topples over the lofty mountains. To this day his name is the common word for earthquake in these dialects. Again, one of the titles of Xmucane is *Chirakan Xmucane* (p. 22).

The terminal *rakan* in these names is a word used to express greatness in size, height or bigness. Many examples are found in Coto's *Vocabulario.* He says

"**Larga cosa:** Lo ordinario es poner *rakan* para significar la largura "de palo, cordel, etc.: para decir, larga caballera trae aquella muger, "dicen: *nahtik rakan ru ri lae ixok.*"

For a person tall in stature he gives the expression *togam rakan:* for large in body (grande del cuerpo) the Cakchiquel is *naht rakan.* But the most appropriate entry in this connection is that in which he gives us the Cakchiquel of *giant:*

"**Gigante:** *hu rapah rakan chi rinak, hu chogah rakan chi rinak;* este "nombre se usa de todo animal que en su specie es mas alto que los "otros. Meo. P^e Saz, serm. de circumsciss. dice del Gigante Golias: "*tugotic rogoric rakan chiachi* Gigante *Golias.*"

Here we find the exact combination, *Hu-rakan,* used in the signification of the greatest of a kind, gigantic, colossal. Among the Northern Indians the notion prevailed that each species of animal included one enormous one, much larger than the others, to whom others were subject, and which

was the one who often appeared to the Indian in his "medicine dreams." This was apparently, from the expression of Father Coto, also the opinion of the Guatemalan tribes, and to this mythical giant specimen of the race they applied the term *hu-rapa-rakan*, "the one exceeding great in size." This idea of strength and might is of course very appropriate to the deity who presides over the appalling forces of the tropical thunder storm, who flashes the lightning and hurls the thunderbolt.

It is also germane to the conception of the earthquake god. The first syllable, *cab*, means twice or two or second; and apparently has reference to *hun*, one or first, in *hurakan*. As the thunderstorm was the most terrifying display of power, so next in order came the earthquake. Were it allowable to alter the initial *c* into the guttural $\overset{c}{c}$, giving us $\overset{c}{c}$*ab rakan*, then the name would mean "the mighty hand."

The name *Chirakan* as applied to Xmucane may have many meanings; *chi* in all these dialects means primarily *mouth*; but it has a vast number of secondary meanings, as in all languages. Thus, according to Coto, it is currently used to designate the mouth of a jar, the crater of a volcano, the eye of a needle, the door of a house, a window, a gate to a field, in fact, almost any opening whatever. I suspect that as here used as part of the name of the mythical mother of the race and the representation of the female principle, it is to be understood as referring to the vaginal cleft, the *ostium vaginæ*, from which, as from an immeasurable *vagina gentium*, all animate life was believed to have drawn its existence.

The same syllable occurs as a prefix in another female name, *Chimalmat*, the mother of Cabrakan (p. 34). This name may, with an effort, be derived from Cakchiquel roots, but as it is absolutely identical with one of a goddess well known in Aztec mythology, I shall consider it later. Suffice it to say here that the verb *malmot*, according to Varea, means to enter suddenly, to appear unexpectedly.

If the derivation of Hurakan here presented is correct, we can hardly refuse to explain the word as it occurs elsewhere with the same meaning as an evidence of the early influence of the Maya race on other tribes. It would appear to have been through the Caribs that it was carried to the West India islands where it was first heard of by the European navigators. Thus the *Dictionaire Galibi* (Paris, 1743) gives for "diable," *iroucan*, *jeroucan*, *hyorokan*, precisely as Coto gives the Cakchiquel equivalent of "diablo" as *hurakan*. This god was said by the Caribs to have torn the islands of the West Indian archipelago from the mainland and to have heaped up the sand hills and bluffs along the shores.* As an associate or "captain" of the hurricane, they spoke of a huge bird who makes the winds, by name *Saracon*, in the middle syllable of which it is possible we may recognize the bird *raku*, which, as we shall shortly see, the Kiches spoke of as the messenger of Hurakan.

* De la Borde, *Relation de l'origine, etc., des Caraibes*, p. 7. (Paris, 1674).

I shall add here an invocation to Hurakan which is one of the finest in the Popol Vuh :

1. Acarroc, Atoob u gih, at Hurakan, at u Qux cah, uleu !
   Hail, beauty of the day, thou Hurakan, thou (its) Heart, the Sky, the Earth !
2. At yaol rech ganal-raxal, at pu yaol mial, qahol !
   Thou giver (of) our prosperity, thou, and giver (of) daughters, sons !
3. Ch'a tziloh, ch'a maquih uloc a raxal, a ganal :
   Make firm, extend hither thy glory, thy greatness :
4. Ch'a yatah u qazsic, vinakiric v'al nu qahol :
   Give their life, (their) increase to my descendants :
5. Chi pog-tah, chi vinakir-tah, tzukul ave, cool ave,
   That they may beget, may increase nurses for thee, guards for thee,
6. Ziquiy ave pa be, pa hoc, pa beya, pa xivan, xe che, xe caam.
   Who shall invoke thee in the roads, in the paths, in the water ways, in the gorges, under the trees, under the bushes.
7. Ch'a yaa qui mial, qui qahol ;
   Give to them daughters, to them sons ;
8. Ma-ta-habi il-tzap, yanquexo ;
   Let there not be disgrace, misfortune ;
9. Ma-ta ch'oc qaxtokonel chiquih, chi qui vach.
   That not comes the deceiver behind them, before their face.
10. M'e pahic, m'e zokotahic ; m'e hoxonic, m'e gatonic.
    May they not fall, may they not stumble ; may they not hurt their feet, may they not suffer pain ;
11. M'e kahic r'equem be, r'ahzic be.
    May they not fall in the low road, in the high road.
12. Ma-ta-habi pak, toxcom chiquih, chi qui vach.
    Let there nót be a stumbling block, a scourge behind, before their face.
13. Que a yatah pa raxa be, pa raxa hoc ;
    Give them (to be) in a green road, in a green path ;
14. Ma-ta-habi qu'il, qui tzap a cuil, av'itzmal.
    Let there not be to them evil, to them misfortune (from) thy locks, thy hair.
15. Utz-tah qui qoheic tzukul ave, cool ave ch'a chi, ch'a vach.
    Fortunate to them (be) existence, nurses thine, guardians thine, be-before thy mouth, before thy face,
16. At u Qux cah, at u Qux uleu, at pizom Gagal ! at puch Tohil !
    Thou its heart the sky, thou its heart the earth, thou veiled Majesty ! thou and Tohil.
17. At puch Tohil, Avilix, Hacavitz, pam cah, u pam uleu, cah tzak, cah xucut.
    Thou and Tohil, Avilix, Hacavitz, body (of the) sky, its body the earth (with its) four sides, four corners.

18. Xa-ta zak, xa-ta amag, u pam ch'a chi ch'a vach, at Qabauil!
So long as light, so long as time, (be) its body before thy mouth before thy face, thou God!

1. *Acarroc* is an interjection of admiration or awe. *Atooh* is the plural form with intensive signification of *ato*, beautiful, fine, good.

2. *Ganal-raxal*, literally "yellowness, greenness." I shall refer to this combination in a later paragraph.

At pu, thou and, read "and thou;" the copulative conjunction in Kiche, like the Latin *que*, often follows the first word of the connected clause.

3. *Ch'a tziloh*; both Ximenez and Brasseur translate this "turn thee;" but this requires *tzeloh*, and is less germane to the sense of the passage. The color terms, *rax*, *gan* again appear in their metaphorical senses of prosperity.

4. *Vinakiric*, form the root *vin*, to increase, gain.

9. *Qaxtokonel*, the liar; *qaxtog* is the usual word for *demonio*, *diablo*, in the religious language.

10. *M'e koxonic, m'e gatonic*; Ximenez, and following him Brasseur, translate this, "May they not fornicate, may they not be brought before the judge;" but the meanings in the text are also given to these words in Ximenez' own *Tesoro de las tres Lenguas*, and are much more likely to have been the original ones.

14. *A cuil av'itzmal*; thy locks, thy hair. This probably has reference to a myth or superstition about the storm god's strength, lying, like Samson, in his hair.

16. *Pizom Gagal*; Ximenez translates "envoltorio de gloria."

17. *At puch Tohil*; read: "And thou (also) O Tohil, etc. *Pum*, from *pa*, in, means "the contents of anything hollow," hence entrails, and generally belly. Ximenez translates it here *vientre*, but "body" is probably nearer the right sense, as it stands in antithesis to *heart* in the previous line.

There is another invocation in the Popol Vuh containing some other names of deity, a literal translation of which I shall give, after Brasseur:

"Hail! O Creator, Maker! Who sees and hears us! Do "not leave us; do not desert us. O Qabauil, in the sky, on "earth, Soul of the Sky, Soul of the Earth. Give us children, "posterity [as long as] the sun goes, and the light. Let the "seed grow, the light come. Many green paths, green roads, "give us; in peace, in white peace, be the tribe; in welfare, "in white welfare, be the tribe; give us then happy life and "existence, O Hurakan, Chipi-cakulha, Raxa-cakulha, Chipi-"nanauac, Raxa-nanauac, Voc, Hunahpu, Tepeu, Gucumatz, "Alom, Qaholom, Xpiyacoc, Xmucane, Grandmother of the

"Sun, Grandmother of Light; let the seed grow, the light "come." p. 210.

Such was the prayer, which according to Kiche traditions, their early ancestors addressed to the divinities, in those far-off years when they dwelt in the distant Orient, in the fertile land of Paxil and Cayala, before they had yet gone to Tulan to receive the tribal and family gods which they adored in later days.

There is no trace of Christian doctrine in these names ; clearly they are all handed down from a generation who knew nothing of missionaries and their teachings. Most of them I have already analyzed, and I shall now take up the remainder.

The term *Qabauil* is in Kiche the generic word for divinity. Thus we find in the Popol Vuh such expressions as : *Xavi e qabauil,* truly they were gods (p. 34) ; *are u bi ri qabauil,* this is the name of God (p. 8). It is from the root *qab,* for the correct signification of which we must perhaps go to the Maya, where it means to create, to make out of nothing. (*Chab,* crear, sacar de la nada, Pio Perez, *Diccionario de la Lengua Maya.*). The word had so many heathenish associations that the Franciscan missionaries dropped it, and substituted the Spanish *Dios,* from which they formed derivatives according to the rules of native grammar. Thus Coto translates *divina cosa* by *diosil* and adds : "antiguamente decian *gabovi al,* de *gabo-* "*vil,* nombre del dios que adoraban." He gives other derivatives, also :

"**Idolatrar:** *qui gabovilan ;* idolo, *gabovil.* * * Lo mesmo dicen de las "pinturas que antiguamente hacian ; *gabul* vel *gabuil. Gabuilhay,* casa "de idolatria ; *gabuil chahal,* el sacerdote, vel guarda de los idolos."

Father Varea seems to derive *gabuyl* from *g'ibak,* to paint :

"**Gabuyl:** estatua o ydolo propriamente de bulto ò pintada la figura ò "ymagen de lo q adoraban los gentiles."

The Dominican missionaries, however, in their writings in the native language adopted *gabuyl* as the correct rendering of *Dios,* God, and this difference of opinion between them and the Franciscans led to some acrimonious linguistic polemics.

Father Hieronimo Roman, from the narratives at his command, states that the name was that of a definite being, the supreme God of the natives of Guatemala.*

The names *Chipi-nanauac, Raxa-nanauac,* are supposed by Brasseur to refer to the Aztec divinity Nanahuatl. They are, however, easily explicable by the Kiche itself. They are derived from the root *nao,* to know, understand, absolute form, *qui nao,* which, says Coto, "signifies everything, which is known or learned by custom or experience ;" *naoh,* is understanding, reason, intellectual power ; *ahnaoh* is the Cakchiquel for *artium magister.* It also applies to understanding the thoughts of another ;

* "El Dios que tenian por supremo, como nosotros, llamavanlo en la Provincia de Guatemala Cabouil." *Republicas del Mundo, Tercera Parte, De la Republica de las Indias Occidentales.* Lib. ii, Cap. xv.

Padre nonohel ka zih, the Father understood our story. In a derived application it signified that mysterious and supernal knowledge which the magician and diviner possess, and which, in its highest form, is the peculiar attribute of divinity. In this sense it is synonymous with *puz*, which I have already discussed, and both are given by Coto as the words for magic and necromancy. Both are also employed together in various passages of the Popol Vuh. Thus it is said (p. 10) that in the beginning the mountains and the valleys, the cypresses and the pines were created instaneously by miracle, by magic, *xaki naual, xaki puz*; so it is said of the formation of the first men that it was by enchantment, by sorcery—*xa puz, xa naual qui tzakic* (p. 198). The expression *nanauac*, therefore has no reference to Aztec myth but to the supernatural power of Divinity, and probably especially to the psychical and intellectual manifestation of the divine energy.

The radical of these comprehensive words is *na*, to feel, to preceive (sentir, advertir, Varea). The reduplication appears in the forms *ta nana*, look, *nanoh*, appointed, designated, and is common in the Maya derivatives from this root, as appears, for instance, in the following entry from the *Diccionario de Motul*:

"**Nanaol:** considerar, contemplar, entender y arbitrar."

The following are definitions from Varea:—

"**Naoh:** el sentido, el uso, la experiencia, el arte, la industria, el buen "ingenio en los hombres, y el instinto natural en los brutos.

"**Naohih:** hacer algo los animales con buen instinto: y tambien hazer "el hombre algo con prudencia, arte, buen uso o tiento con entendi-"miento.

"**Naohticah:** enseñar ò doctrinar costumbres, artes, letras, cosas "buenas ô malas.

"**Nanoxin:** tener muy de memoria algo.

"**Naval:** creyan que avia cosa viva dentro del arbol, piedra ò monte que "hablaba, llamaba [hence *naval che*, spirit of the tree, *naval abah* spirit "of the stone].

"**Navalih:** hazer milagros de echizeros encantos.

"**Puz Naval:** era una manera de nigromancia ô magica que usaban los "yndios tranformandose en globos de fuego y en aguila y otros animales "que yban por el ayre."

The process of thought seen in these derivatives is interesting to note. From the simple use of the senses (*na*), come experience, knowledge, ability, skill (*naoh*), he who has these to a great degree can do more than others, he can work wonders (*navalih*); he can understand the voices of nature which speak in the babbling brook, the moaning of the wind, the crackling fire, the rattling stones (*naval*); and in his highest attainments may transform himself into any other form of existence (*puz naval*).

Such is the testimony which these rude natives bear through the witness of their language to the source and power of knowledge; and such

was the impression it made upon their untutored minds that even to-day, after more than three hundred years of Christian teaching, it is : the mild Judean Virgin, nor the severe Christian God who is their hi... deity, but it is the wise Naoh, the Spirit of Knowledge, the Geniu: Reason, who in secret still receives their prayers as the greatest of all gods. They have also other divinities whose worship has constantly be: retained in spite of all the efforts of the missionaries.*

The word *naual* appears also to have been used to express that intelle tual communion with the lower animals which the priests often claim to the effect that they could understand the songs of birds, etc. Coto re marks that the natives had the superstition that twins are by birth ... to rats, "that is, that they have the characteristics of rats, that they w gnaw the clothing of those who irritate them," etc.†

The name *Voc* is that of a species of bird (Cakchiquel *Vaku*). Coto scribes it as having green plumage, and a very large and curved apparently a kind of parrot. Elsewhere in the myth (p. 70) it is said be the messenger of Hurakan, resting neither in the heaven nor in the derworld, but in a moment flying to the sky, to Hurakan who dwells ther

The tribal gods are first mentioned in the last part of the Popol Vuh, an they are said to have been given the people in "Tulan Zuiva," a tow where they went to receive them (p. 215). The Tecpan-Atitlan re state that these gods were first given "in Tullan in Xibalbay," one of four places of the name of Tulan, which that ancient and interesti legend refers to. The names of these gods were Tohil, Avilix, Hacav and Nicahtagah.

* "Die bedeutendsten Gottheiten der Indianer von Istlávacan, denen sie no bis zur Stunde zu gewissen Zeiten im Geheimen, im düsteren Urforst op und zu deren Ehren sie zuweilen sogar Feste begehen, heissen: Noj, der Ge der Vernunft, Ajmak, der Genius der Gesundheit, Ik, der Mond, Kanil, der nius der Aussaat und Juiup, der Gott der Erde, welcher unter den Indianern böse Princip vorstellt, im Gegensatze zu Kij, dem Gott des Lichtes, dem gu Princip." Dr. K. Scherzer, *Die Indianer von Santa Catalina Istlávacan*, p. These Indians are said to be the pure-blooded descendants of the anc Kiches. Of these names Noh, Naoh, is explained above; Ahmak is the na of a day in the calendar, meaning uncertain; Ik, the moon; Kanil, ye refers to the color of maize when ripe and hence the harvest; Juiup, prob *uliu* the earth; Kij = g'ih, sun, day, light, &c. Dr. Scherzer says that they look upon mountains, trees, etc., as habitations of particular gods. He also that to this day among them every child at his birth is named after an under the protection of some species of animal; and this animal is ... *nagual* or *nawal*. In one curious episode in the Popol Vuh where the sent forth to the bath two beautiful maidens in order to seduce the god is related that what they wished was that these virgins should be deflo *qui naual Tohil*, by the mystic power of Tohil (p. 268). The verb *noh* has the nification to fill, and hence to impregnate, fecundate, and is often so used in Popol Vuh (*e. g.* p. 12). This gives occasion for a combination of genesia and myths with the worship of Reason.

† That particular form of superstition called *Nagualism*, which still pre among some Central American nations, derives its name from this root. been described by the Abbé Brasseur in his *Voyage sur l'Isthme de T huan* Paris, 1861, and in the *Bull. de la Soc. de Geographie, Paris*, Ser 1, xiii.

Tohil is supposed by Ximenez to be the same as Toh, which is the 9th day of the calendar, and is the sign of rain. Brasseur thinks the orthography should be *Tohohil*, which is from a verb *tohoh*, meaning to sound, resound, make a loud noise, and has relation to the thunder, the legend saying that Tohil produced fire for men by striking his shoe. This derivation he bases on a passage in the *Records from Tecpan Atitlan* where there is apparent reference to this divinity, with a derivation from *tohoh*. It is as follows: After an important battle in the early days of their history, the tribes gathered together on a great mountain, Tepeu Oloman, and there consulted as to measures of safety. The *Records* read:

"Tok xka qutubeh qa ki, ha xa colovi avi, xoh cha chi re
"When we asked one another whence our comfort, to us then spoke
"Qeche vinak: Xaqui tohoh quihilil xibe chi cah, xa chi cah xhe
"the Kiche men: It has sounded loudly above in the sky, from in the sky
"nu colo vivi Xcha quere qa xubinaah vi
"our comfort will be. Thus was said (and thus) came the name
"Tohohil ri.
"*the Loud-Sounding* to them.

The derivations of a number of other tribal names are given in the same passage, but it is probable, like many in other ancient records, the derivations were altogether an afterthought, and were attached at a late date to the ancient legend.

It is impossible, however, to obtain *Tohil* from *tohoh* without straining the rules of derivation in their language. On the other hand, it may be very correctly explained as the determinative form of the verb *toh*, a root common to this whole linguistic family. The primitive meaning of this monosyllable seems to have been to give what is due, to pay what is owed. In one sense, we do this in paying debts, in another in punishing an enemy, in yet another in telling the truth where it is properly expected of us. The man who does all this does right, he is just, he causes strife to cease, and pacifies his neighbors; as such, he is a good, sound, healthy man, free from infirmities. That this was the course of thought in the development of this root will be clearly seen by the following extracts from that admirable monument of linguistic industry, the *Diccionario de Motul*:

"**Toh**: v. pagar deudas.
"**Toh**: s. la verdad; lo que es verdad ó verdadero.
"**Toh**: s. venganza.
"**Tohil**: derechura, ó lo derecho y justicia.
"**Tohalol**: estar bueno ó consolado.
"**Tohancilol**: estar bueno de salud; descuidarse, asegurarse.
"**Tohcinahol**: consolar ó quietar y pacificar: y asegurar deuda.
"**Tohol**: sano, sin enfermedad.

Such is the group of ideas which were associated in the native mind with the name and character of *Tohil*. He was the Just one, he distributed equitably to men their rewards and their punishments, he was the Com-

forter, the Avenger, who protected and consoled. He it was, according to the legend, who gave the inestimable blessing of fire to men, obtaining it by striking his shoe (p. 218). As the deity who was looked up to by the Kiche as their benevolent guide, teacher and guardian, the native writer identified him with the Mexican Quetzalcoatl, the mythical founder of the Nahuatl civilization (p. 246) ; but this must not be taken too literally, as the assertion itself only shows the general similarity of character between these two deities, and is far from being sufficient to prove their historical identity.

No derivations whatever have been suggested for Avilix and Hacavitz. The latter, I think, is a compound of *hak, haka*, to open, disclose, reveal, and also to listen to ; and *vix*, which means primarily a root, but which in a metaphorical sense meant ancestors ; as Varea says :

"**Vix:** la rayz de todo arbol. * * A sus padres llaman tambien los "Indios, *ru vixil;* dicenlo tambien de nuestros primeros Padres, Adan "y Eva."

The sense would be, He who listened to our Ancestors.

The mythical ancestors of the royal Cakchiquel family of the Xahila were $^{c}_{c}$ *a* $^{c}_{c}$*avitz* and *Zactecauh.** If, as seems probable, the former is a compound of $^{c}_{c}$ *a* $^{c}_{c}$ *al*, royal, *vix*, root stem, stirps, a very natural meaning appears in the name ; $^{c}_{c}$ *a* $^{c}_{c}$ *al* itself, is, according to the *Calepino* of Varea, a derivative from $^{c}_{c}$ *a* $^{c}_{c}$ fire or flame, through the same easy analogy which leads us to associate brightness with glory and greatness.

I have not found a clear derivation for Avilix ; but it is probably from the verb *ylin*, future *xavilah*, to protect, care for.

The compound Nicah-tagah is plain enough—*nigah*, the middle, *tagah*, a plain, a sea-coast, a town. This is given by Brasseur. But one point escaped his notice, which throws another light on the mythological significance of this deity. By a transfer common in most languages, the word for middle was also applied to the organs of generation (las verguenzas de hombre ô muger, Varea, *Calepino*). This divinity holds an inferior place, and indeed is, I believe, not again mentioned in the legend.

I now pass to the curious episode of the descent of the hero-god or gods, Xbalanque, into the underworld, Xibalba, his victory over the inhabitants, and triumphant return to the realm of light. The exploits of this demigod are the principal theme of the mythological portion of the Popol Vuh.

It was the vague similarity of this myth to the narrative of the descent of Christ into Hell, and His ascent into Heaven, to which we owe the earliest reference to these religious beliefs of the Guatemalan tribes ; and it is a gratifying proof of their genuine antiquity that we have this reference. Our authority is the excellent Bishop of Chiapas, Bartolome de

* *Records from Tecpan-Atitlan*, written by Don Francisco Ernantez Arana Xahila, 1573. MSS. in Cakchiquel in my possession.

las Casas, and after him Alonzo Fernandez, and later writers. Their account reads:

"Dicen fué este Dios [Exbalanquen] à hazer guerra al infierno, y peleó "con grande numero de demonios. Vencio los, y prendio al Rey del "infierno, y à otros muchos de los suyos, y bolvio al mundo vitorioso. "Llegando cerca de la tierra, el Rey del infierno pidiò que no le sacasse "de su lugar. Exbalaquen (que asi se llaman este gran Dios) le dio un "empellon, y le bolvio à su proprio Reyno, diciendole; Sea tuyo todo "lo malo, sucio y feo. Viniendo vencedor, no le quisieron recibir los de "Guatemala y Chiapa con la honra que era razon; y por lo cual se fue "à otra Provincia, adonde fué con grandes ceremonias recibido. Re- "fieron que deste vencedor del diablo tuvo principio el sacrificar "hombres."*

Las Casas adds that Xbalanque was born in Utlatlan, which we may construe as merely a claim made by the Kiches to the birthplace of the hero god, which doubtless would have been contested by their neighbors, for there is evidence that we have here to do with a myth which was a common property of the Maya stock. As related in the Popol Vuh where it is told in a confused manner, and at wearisome length, it is briefly as follows:

The divine pair Xpiyacoc and Xmucane had as sons Hunhun-Ahpu and Vukub-Hun-Ahpu (Each-one-a-Magician and Seven-times-a-Magician). They were invited to visit Xibalba, the Underworld, by its lords, Hun-Came and Vukub-Came (One-Death and Seven-Deaths), and accepting the invitation, were treacherously murdered. The head of Hunhun-Ahpu was cut off and suspended on a tree. A maiden, by name Xquiq, Blood, passed that way, and looking at the tree, longed for its fruit; then the head of Hunhun-Ahpu cast forth spittle into the outstretched palm of the maiden, and forthwith she became pregnant. Angered at her condition, her father set about to slay her, but she escaped to the upper world and there brought forth the twins Hun-Ahpu and Xbalanque. They grew in strength, and performed various deeds of prowess, which are related at length in the Popol Vuh, and were at last invited by the lords of the Underworld to visit them. It was the intention of the rulers of this dark land that the youths should meet the same fate as their father and uncle. But prepared by warnings, and skilled in magic power, Xbalanque and his brother foiled the murderous designs of the lords of Xibalba; pretending to be burned, and their ashes cast into the river, they rose from its waves unharmed, and by a stratagem slew Hun-Came and Vucub-Came. Then the inhabitants of the Underworld were terrified and fled, and Hun-Ahpu and Xblanque released the prisoners and restored to life those who had been slain. The latter rose to the sky to become its countless stars, while

* Las Casas, *Historia Apologetica de las Indias Occidentales*, cap cxxiv (Madrid edition): P. F. Alonzo Fernandez, *Historia Ecclesiastica de Nvestros Tiempos*, p. 137. (Toledo, 1611).

Hun-hun-Ahpu and Vucub-Hun-Ahpu ascended to dwell the one in the sun, the other in the moon.

The portion of the legend which narrates the return of Xbalanque to the upper world, and what befell him there, as referred to in the myth preserved by Las Casas, is not preserved in the Popol Vuh.

The faint resemblance which the early missionaries noticed in this religious tradition to that of Christ would not lead any one who has at all closely studied mythology to assume that this is an echo of Christian teachings. Both in America and the Orient the myths of the hero god, born of a virgin, and that of the descent into Hades, are among the most common. Their explanation rests on the universality and prominence of the processes of nature which are typified under these narratives. It is unscientific to attempt to derive one from the other, and it is not less so to endeavor to invest them with the character of history, as has been done in this instance by the Abbé Brasseur (de Bourbourg), and various other writers.

The Abbé maintained that Xibalba was the name of an ancient State in the valley of the Usumasinta in Tabasco, the capital of which was Palenque.* He inclined to the belief that the original form was *tzibalba,* which would mean *painted mole,* in the Tzendal dialect, and might have reference to a custom of painting the face. This far-fetched derivation is wholly unnecessary. The word Xibalba, Cakchiquel Xibalbay, Maya Xibalba, Xabalba or Xubalba (all found in the *Diccionario de Motul,* MSS.), was the common term throughout the Maya stock of languages to denote the abode of the spirits of the dead, or Hades, which with them was held to be under the surface of the earth, and not, as the Mexicans often supposed, in the far north. Hence the Cakchiquels used as synonymous with it the expression "the centre or heart of the earth."

{ *ch'u qux uleu*
{ in its heart the earth. (Coto *Dicc.* s. v.).

Coto adds that the ancient meaning of the word was a ghost or vision of a departed spirit—"antiguamente este nombre *Xibalbay* significaba el de-"monio, vel los diffuntos ô visiones que se les aperescian, y asi decian, y "aun algunos ay que lo dicen oy, *xuqutzii xibalbay ri* $\overset{c}{\underset{c}{}}$ *etzam chi nu vach,* "se me apereció el diffunto."

After the conquest the word was and is in common use in Guatemala dialects to mean *hell,* and in Maya for *the devil.* Cogolludo states that it was the original Maya term for the Evil Spirit, and that it means "He who disappears, or vanishes."† He evidently derived it from the Maya verb *xibil,* and I believe this derivation is correct; but the signification he

* *Dissertation sur les Mythes de l'Antiquité Americaine,* § viii (Paris, 1861); see also his note to the *Popol Vuh,* p. 70.

† "El Demonio se llamaba *Xibilha,* que quiere decir el que se desparece ó desbanece." *Historia de Yucathan,* Lib. iv, cap. vii. Cogolludo had lived in Yucatan twenty-one years when he was making the final revision of his History, and was moderately well acquainted with the Maya tongue.

gives is not complete. I quote from the *Diccionario de Motul*, MSS. the entry relating to this word :

"**Xibil,** *xibi, xibic :* cundir como gota de aceita ; esparcirse la comida en "la digestion, y deshacerse la sal, nieve ó yelo, humo ó niebla.

"*item :* desparecerse una vision ó fantasma.

"*item :* temblar de miedo y espantarse.

"*item :* quitarse el dolor y la calentura."

In the Cakchiquel we have the same word *xibih*, to frighten, to terrify, from which are derived the instrumental form *xibibeh*, the verbal noun *xibibal*, that which causes terror (*e. g.*, *xibibal gel*, lit. "that which frightens birds," *i. e.* the scarecrow set up in the cornfields, Varea), etc. This is the secondary meaning of the root, and is the only one which seems to have survived in the Guatemala dialects. The original signification of the word was undoubtedly "to melt, dissolve," thus disappear, and in this sense it was applied to the act of death, the disappearance of man from this mortal life.

It is most interesting in this instance to note how the mental processes of these secluded and semi-barbarous tribes led them to precisely the same association of ideas which our greatest dramatist expresses in the opening lines of Hamlet's famous soliloquy :

"O, that this too too solid flesh would melt,
Thaw, and resolve itself into a dew ; "

And which Cicero records in the expression *dissolutio naturæ* in the sense of death (*De Legibus I. ii. et al.*).

The natural terror and fright with which death and ghosts are everywhere regarded, and especially, as Landa remarks, by this people,* explains how this secondary meaning became predominant in the word. The termination *ba* means in the Guatemala dialects, where, whence, whither, *bey*, a path or road ; *Xibilbay* thus signifies, in its locative sense, the place where they (*i. e.* the dead) disappear, the Hades, the Invisible Realm, which, as I have above appointed out, was supposed to be under the ground.

It was a common belief among many tribes in America, as I have elsewhere shown,† that their earliest ancestors emerged from a world which underlies this one on which we live, and in ancient Cakchiquel legend, the same or a similar notion seems to have prevailed. At least, such I take to be the sense of a passage in the earlier pages of the *Memorial de Tecpan-Atitlan*, which I shall transcribe from the copy in my possession, with the translation of the Abbé Brasseur, which, however, by his own statement, cannot be depended upon as accurate.

"Tan qa talax ri Chay Abah, rumah raxa Xibalbay, gana Xibalbay tan "qa ti qak vinak ruma qakol bitol ; tzukul richin ri Chay Abah ok xqak "ri vinak pan pokon qa xutzin vinak.

* *Relacion de las Cosas de Yucatan*, § xxxiii.

† *The Myths of the New World*, p. 241 (second edition).

"Le Chay Abah est sorti de Xibalbay, du riche et puissant Xibalbay.
"L'homme est l'euvre de son createur et formateur, et celui qui sou-
"tiens le Createur c'est ce Chay Abah. Or il forma l'homme et le per-
"fectionna dans le douleur."

The name of the hero-god Xbalanque is explained by the Abbé Brasseur to be compounded of the diminutive prefix *x*, *balam* a tiger and the plural termination *que*.* Like so many of the derivations offered with great confidence by the worthy Abbé, this one is quite incorrect. There is no plural termination *que*, neither in the Kiche nor in any related dialect; and the signification "tiger" (jaguar, *Felix unca* Lin. in Mexican *ocelotl*), which he assigns to the word *balam* is only one of several which belongs to it.

The name is compounded of the prefix, either feminine or diminutive *x*; *balam*, or, as given by Guzman, *balan*;† and *queh*, deer. This is the composition given by Ximenez, who translates it literally as "diminutivo de tigre y venado."‡

From analogies easy to perceive, the name *balam*, was also applied to a class of warriors; to a congregation of priests or diviners; and to one of the inferior orders of deities. In composition it was applied to a spotted butterfly, as it is in our tongue to the "tiger-lily;" to the king-bee, to certain rapacious birds of prey, etc.

I quote the following entries in the manuscripts before me:

"**Balam:** tigre.
"**Balam malax:** mariposa grande.

GUZMAN, *Compendio de Nombres.*

"**Balamil cab:** el rey de abejas.
"**Balamil cah:** los sacerdotes del pueblo, cacique y regidores, que
"con su fortaleza lo guardan.
"**Balamil chich:** aves de rapina.

"*Diccionario de Motul.*

"**Balam:** el tigre, *Zakbalam*, tigre pequeño de su natureleza; $\overset{c}{c}$*ana balam*,
"el grande.
"**Balam:** tambien sig^a un signo de los Indios. *Maceval* $\overset{c}{c}$*ih P^o balam*,
"ô *Maria xbalam*. *Balám* se llama el echizero.

Varea, Calepino.

In the last entry quoted, we find that *balam* was the name of one of the days of the Kiche-Cakchiquel calendar. It was in fact the twelfth of their week of twenty days, and in the Mexican calendar *ocelotl* stood for the fourteenth of the twenty days. *Queh*, the deer, was also the name of a sign or day, the seventh in the Kiche-Cakchiquel calendar; but was also used to ex-

* "Les Petits Tigres," *Mythes de l'Antiquité Américaine*, § viii; *Popol Vuh*, p. 34, note.

† *Compendio de Nombres en Lengua Cakchiquel. MSS.*

‡ *Las Historias del Origen de los Indios*, p. 16.

press two, thirteen, five or six days, as is stated by Varea in the following entry in his *Calepino.*

"*Queh :* el venado. Ha se estendido la significacion à mulas, caballas "y machas. Sigª un cierto dia ; otras veces dos dias ; otras veces es signo "de trece, otras veces cinco ò seis dias à la quenta de los Indios : *xa hun* "*queh vœ* $^{c}_{c}$*ih,* ò, *cay queh, voo quch, vahaki,* ò, *oxlahuh queh.*

It is not easy to explain the principles which governed the calculation of time among the Kiche-Cakchiquel tribes, only vague and contradictory accounts concerning it having reached us, the analysis of which I trust to undertake in another article. Suffice it to say here that the hero-god whose name is thus compounded of two signs in the calendar, who is born of a virgin, who performs many surprising feats of prowess on the earth, who descends into the world of darkness, and sets free the sun, moon and stars to perform their daily and nightly journeys through the heavens, presents in these and other traits such numerous resemblances to the Divinity of Light, reappearing in so many American myths, the Day-Maker of the northern hunting tribes, that I do not hesitate to identify the narrative of Xbalanque and his deeds as one of the presentations of this widespread, this well-nigh universal myth, guarding my words by the distinct statement, however, that the identity may be solely a psychological, not a historical one.

It will not be without interest to trace the *balam* myth in its later development. We see in the quotation from the *Diccionario de Motul,* that the title was applied to the priests, chief and rulers on whom the defence of the city rested. There were also, in Yucatan, four certain divinities closely connected with the Calendar, called the *Bacabab.* The myths of these correspond in a general way with that of Xbalanque, sufficiently so to recognize that they played a corresponding part, and the *balam* and the *bacab* have been identified in modern Maya superstition. The four *bacabab* were four giants (*chaac*) who sustained the heavens, presided over the years, were the gods of rain and agriculture, who sent the winds on their swift journeys, and hurled the lightning flash from the heavens. The memory of these mighty beings is still preserved by the native Mayas of Yucatan, and even with all their devotion to the Romish Church, they do not neglect the pious rites to these ancient and beneficient national divinities ; and what is to my purpose here, is the fact that they still pay them homage under this very name of the *Balams.* In Maya the plural termination is *ob,* and with the masculine prefix *h,* their name becomes *Hbalam ob.*

I have in my possession a Spanish manuscript written in Yucatan about twenty years ago, in which are collected various superstitions still prevalent among the natives. The accounts are from different sources, and as the matter is both new to students of such matters and of importance in tracing the development of the religious notions of the natives, I shall give a translation of those paragraphs which describe the still prevalent belief in the Hbalamob. The authorities given for the account are the

eminent antiquary, Don Crescencio Carrillo, Don Jose Maria Lopez, and the Licenciate Zetina of Tabasco.

"The *Hbalamob* are certain very ancient men who take charge of and "guard the towns. One of them is constantly on the watch on the "north side of the town, another on the south, a third on the east, and "a fourth on the west. During the day they are invisible, although "they are occasionally seen; but those who have this privilege are very "sure to meet soon afterwards with some serious misfortune, as to be "stricken dumb for a while, or to be attacked with a dangerous malady.

"As soon as night arrives the Hbalam becomes more alert and vigilant, "without which the town would soon suffer great misfortune. A violent "rain, a hurricane or a plague would promptly visit it. Although rarely "seen even at night, one may often hear the shrill whistle with which "they call to each other for assistance in repelling the malignant in-"fluences which would assail the town. These the native represents to "himself as personified in individuals, as did the ancient Romans and "Greeks.

"The whistle which is their signal to each other is so loud and shrill that "it can be heard from one end of the town to the other, no matter how "far that may be. United, they oppose with all their might the malig-"nant powers which would attack the town. Such is their gigantic "strength that the day after a conflict of this kind one will find the "arena of the contest strewn with large trees broken down, torn up by "the roots and split into fragments, and the earth is beaten and up-"heaved in a manner that could not proceed from any human agency; "even large stones have been broken into pieces in such battles.

"Although the Hbalam has no wings, he has the power of flying through "the air.

"Not only the natives but the whites of the interior have implicit faith in "these mysterious beings. There is not an Indian who has a corn-field "who omits to propitiate on the proper day the Hbalamob by a suita-"ble offering. This is a very ceremonious act which is presided over by "the *hkin* (native priest), and were it neglected, the corn would wither "for want of rain or for some cause be ruined.

"When an Indian is reproached with the error of believing in the exist-"ence of these Hbalamob, which he has never seen, he contents him-"self with the reply; '*Ah! bix-maheb hah!*' 'Ah! How can it be "otherwise than true!'

"They are, however, seen on various occasions. Thus they say that an In-"dian and his wife once went to their cornfield to gather ears. While "at work the Indian left the field to get some water, and his wife threw "off the gown she wore lest it should be torn, and was naked. Sud-"denly she heard some one call to her in a loud voice: '*Pixe auito* "*xnoh cizin*': (*Tapa ta culo, gran diablo*); at the same time she received "two smart blows with a cane. She turned and saw a tall man with "a long beard and a gown which reached to the earth at his feet.

"This was the Hbalam. He gave her two more blows and disappeared, "and she bore the marks of the four cuts the rest of her life.

"At another time, in the province of Tihosuco, an Indian had forgotten to "offer the Hbalam a gift when the corn was planted. As the ears were "about ripening he visited his field to look at them. He found in it a "tall man who was engaged in picking the ears one by one, and placing "them in a *xucac*, or large basket, which, according to the custom of "the country, he carried fastened to his shoulders. The Indian saluted "him with some mistrust. The other, who was, in fact, the Hbalam, "answered the salute curtly and added : 'I am here gathering in that "which I sent.' Shortly afterwards he took from his pouch an immense "cigar, 'such as the Hbalamob are accustomed to smoke' parenthetic-"ally added the narrator, and picking up his flint and steel began to "strike sparks. But the sparks he struck were flashes of lightning, and "the sound of his blows was terrible thunderclaps which shook the very "earth, and the Indian fell to the ground unconscious with terror. "When he came to himself, a hail storm had destroyed his corn. On "his return he fell sick with a fever which nearly cost him his life.

"It is a general belief among the Indians that the shooting stars are "nothing else than the stumps of their huge cigars thrown away by the "Hbalamob."

Returning to the myth of Xbalanque, it is evident that in the Popol Vuh one important part of it is omitted, that is, the portion describing his actions after returning from the underworld, and we can but meagrely supply this omission from other sources. According to the earliest authorities, his egress was made at Coban in Vera Paz, and after he had come forth he stopped up the aperture or cavern, so that no other one could descend.*

The divinities Hun Batz and Hun-choven are represented in the Popol Vuh as skilled in painting, singing, playing the flute, in working gold and jewels, and in cutting stones. Several meanings can be given to each of these names. Hun-Batz is translated by Ximenez *a thread ;* its proper form is Baq, in Cakchiquel, from the verb to spin, weave, and I presume refers to Hun-Batz as presiding over the textile arts. Hun-choven is stated by Ximenez to mean *one who is neat* (uno que esta en orden) ; by Brasseur, *un qui s'embellit.* The verbal form *chove* is rendered by Varea "blanquearse," to whiten, bleach or polish up. This, too, seems to bear a distinct reference to the arts. Their mother is Xbakiyalo, from *x*, female prefix, *bak*, bone or bones, and *yaloh*, to keep together. Ximenez translates it literally *tied bones* (huesos atados), but it should be "She who preserves the bones," and probably has reference to the general care with which the bones of the dead were preserved with religious respect by various members of the Red Race.

* Hieronimo Roman, *De la Republica de las Indias Occidentales*, Lib. ii, cap xv. (Salamanca, 1595).

The father of these divinities was Hun-hun-ahpu, himself the son of the original pair, Xpiyacoc and Xmucane.

The Abbé Brasseur has taken pains to make this myth of the two brothers appear to be of Nahuatl origin. On the contrary, there is strong evidence that it is essentially a Maya myth, and originally bore a close relation to others prevailing in Yucatan. This evidence is found in the pages of Father Hieronimo Roman, and I regard the version he gives of so much interest that I will translate it from the third part of his extremely scarce work *Las Republicas del Mundo*, published at Salamanca in 1595.

"Their tradition says that there were a husband and wife who were "divine. The man was called Xchel, and the woman Xtcamna. They "considered these two father and mother, having three sons. The oldest "together with some others grew arrogant, and desired to make creatures "for themselves against the wish of the father and mother; but they "could not, because the work which came from their hands turned out to "be only old earthenware fit for common purposes as for pots and pans, "and other utensils of yet meaner uses. The younger sons who were "called Huncheuen and Hunahan asked permission of their father and "mother to make creatures, and they received it, their parents saying "they might have it because they had demeaned themselves humbly. "They at first made the heavens and the plants, fire, air, water and "earth. Then they made man from the earth. The others who pre-"sumptuously tried to make creatures against the will of the parents "were cast into the infernal regions. All the natives who are engaged "in the arts, such as painters, weavers of feathers, sculptors, workers in "silver and gold, and the like, honor highly these two younger brothers, "and ask their favor and aid in order to obtain skill in their arts and "trades, but they do not believe them to be the highest divinity."*

In this narrative Roman gives the name of Hun ahau (*ahan* is an obvious misprint), instead of Hunbatz ; and assigns to them as parents the distinctively Maya divinities Itzamna, the mythical civilizer and discoverer of picture writing, and Xchel, the goddess of medicine, childbirth, etc., although he confuses the sex of the parents. It is an interesting proof of the antiquity of the legend, and of its extension into the pure Maya speaking communities, with whom probably it was a relic of very ancient myths common to the Maya-Kiche stock.

I have reserved for a special subject of discussion the relationship of some of the names of divinities in the Popol Vuh to those of the Aztec mythology. It is the received and favorite theory with many that the civilization of Guatemala was at first a legacy from some Nahuatl speaking race, either Toltecs or Aztecs. The substantial identity of the mythologies of the two peoples has also been assumed. How far the identity extended, I shall now examine.

* *De la Republica de las Indias Occidentales.* Lib. ii, cap xv. This extract is also given by Garcia, *Origen de los Indios*, Lib. v, cap vi, but he has completely distorted the proper names.

Certainly the native writer of the Popol Vuh claims a common origin with the Nahuatl race. Like them he traces his descent from the mythical seven caves, seven ravines or seven sons which are familiar in Aztec myth. He quotes an ancient song which began with the words *Kamucu*, we see, which ran like this:

"Alas, in Tulan were we ruined, there we separated, there they re- "mained behind, our brothers, our kinsmen. We indeed have seen the "sun, but they, where are they now, now that the day is breaking?

"Thus did our ancestors chant to the priests, the Yaqui men.

"Verily, the god named Tohil is the god of the Yaqui men, Yolcuat "Quetzalcoat by name, when we separated in Tulan, in Zuiva. Thence "indeed came we forth together; there was the common parent of our "race whence we came. So said they one to another.

"Then they called to remembrance their brothers, there, far off, behind "them, the Yaqui men, where the day came, in Mexico, as it is now "called."

The "Yaqui men," *yaqui vinak*, was and still is the common term in Kiche and Cakchiquel for the Aztecs; *yaqui* itself being an adjective in those dialects signifying polished, cultivated, civilized.* There was undoubtedly frequent commercial intercourse between the Aztec and neighboring races, and among the descendants of the original seven brothers were claimed to be such totally diverse races as the Otomis and Tarascos, so that it is not surprising that the early Kiches in a measure accepted an origin from the same prolific source. Tohil and Quetzalcoatl resemble each other in vague outlines, and hence the scribe identified them just as Tacitus identified the Teutonic Thor with the Latin Vulcan. There is no real similarity between the two.

The name Chimalmat also appears in the Quetzalcoatl myth in the form Chimalmatl. According to one account, she was the second wife of the father of men, Iztac-mixcohuatl and the mother of Quetzalcoatl; or she was a virgin, and finding a *chalchihuitl*, a sacred green stone, swallowed it, and becoming pregnant bore Quetzalcoatl; or again she was the wife of Camaxtli, god of hunting and fishing, and had by him five sons, one of whom was Quetzalcoatl.† The name in Nahuatl is from *chamalli*, a shield, and probably *matlalin*, dark green. We find her in the Popol Vuh as the wife of Vukub Cakix, Seven Aras, the ara being the bird of brilliant tropical plumage called in Aztec the Quetzal. Although her name can be explained as a Kiche word, it is most probably a loan from Mexican mythology.

The name *tepeu* which I have derived from a Maya root is found also in

* The Yaqui tribe in Sonora has no connection with this tradition, the identity of names being accidental, and the meaning of the words different. *Yaqui* is also an Aztec word meaning "departed or gone away to some other region," emigrants (ido ó partido para alguna parte, Molina, *Vocabulario Mexicano*, s. v.).

† These various myths are given in Toribio de Motilinia, *Historia de los Indios de Nueva España*, *Epistola Proemial*, p. 10, and Geronimo de Mendieta, *Historia Ecclesiastica Indiana*, Lib. ii, cap xxxiii.

Nahuatl with almost the same significations, as will be apparent from the following quotations from Molina's *Vocabulario Mexicano* (Mexico, 1578).

"**Tepanaui,** el que excede a los otros y les lleva ventaja en algo, ô "el que es vencedor.

"**Tepan nicac,** presidir ô governar (*nicac* is an adverbial ending "signifying presence in time and space, here is, there is).

"**Tepeuani,** conquistador ô vencedor de batalla."

The same may be said of the Kiche and Maya word *ahau*, chief, lord, often applied to divinities ; this, too, reappears in Nahuatl in the sense of enjoyment, ease, taking one's pleasure, as a great ruler is supposed to do. The following are also from Molina.

"*Ahauia,* regozijarse, y tomar placer.

"*Ahauiltia,* espaciarse, recrearse ô pasear tiempo.

"*Ahauixca,* alegremente."

But the careful student in comparing these words and their derivatives in Aztec and Maya will find that while in the latter tongue their whole history can be traced from the primary, literal, concrete meaning through the secondary, transferred and metaphorical senses, this is not the case in Aztec, but that in it they appear only with a late secondary signification. This is conclusive evidence that the borrowing was not from Aztec to Maya, but from Maya or its dialects to Aztec, and this at a comparatively late date in linguistic history.

I shall illustrate this by another example. I have previously traced the development of the name Nanauac from a Maya root, branching off, and extending through an interesting series of related conceptions. Words from this same root are also found in Aztec, but all derived from a late form, and in a bad sense. Molina gives ;

"*Naualli,* bruxa.

"*Naualtatia,* esconderse para asechar ô hacer mal à otro.

"*Naualloti,* negromancia ô cosa semejante."

No other significations are given by Molina to words from this root except such as relate to sorcery and witchcraft. Evidently the Aztecs had borrowed it after it had reached this meaning in its development, and it would be in vain to attempt to show its history from Nahuatl sources, whereas this is easy from the Maya dialects. These examples therefore point strongly to the conclusion that the resemblances or occasional identities between Kiche and Aztec myths are superficial ones only, brought about by a limited but long continued intercourse between the two peoples, and that the main and fundamental conceptions of Kiche mythology do not point to any Aztec or Toltec source, but strongly and decidedly to the pure Maya myths and tongue.

As a probable Aztec infiltration; I may mention the myth of the terrestrial paradise called in the Popol Vuh *Paxil.* This word has given trouble to the commentators, and no satisfactory sense has been made out of it viewed as a Kiche expression. I am inclined to believe it a reminiscence

of the Aztec Tlaloc and his happy abode. He was the god of rain, "distributor of the waters" (repartidor de las aguas), and the joyous spot where he passed his time was called *Pahaà*, properly *Pahatlan*, from *pahatl*, rose water, sweet unguent, or other such substance to strengthen and refresh the body.* The waters, the timely rains, refresh and rejuvenate nature, and whence they come, their source and home, was in the imagination of the Aztecs preëminently the land of life, joy and abundance, the terrestrial paradise.

While I am anxious to give full weight to these affinities between the Maya-Kiche and the Aztec mythology, I must formally protest against the strained efforts at identifying the divinities and myths of the one race with that of the other, as has been done in many parts by Brasseur and in an even more pronounced manner by Mr. H. H. Bancroft.† I wish to state clearly my adherence to the opinion that the theogonies of the Maya and Nahuatl stocks were distinct in origin, different in character, and only similar by reason of that general similarity which of necessity arose from the two nations being subject to like surroundings, and in nearly the same stage of progress. The two nations had for generations frequent commercial intercourse; certain features of the religion of the one may have been borrowed from the other, as were certain words of the language; but to explain the attributes of a Maya-Kiche divinity by those of an assumed Mexican analogue is a hazardous and uncritical proceeding; and to take it for granted that historically the one mythology is a descendant of the other is a gratuitous assumption wholly without support by the facts so far as we know them, and at present contrary to probability.

It will be noticed in some of the above names how prominent the perception of color shows itself. This is very strongly marked in these dialects. There is, however, no evidence that they distinguished colors to a refined extent. On the contrary, Coto distinctly confines the names of colors to five: "Los nombres de colores no tienen mas de cinco" (s. v. *Color*).

As I have above said, travelers maintain that the natives do not distinguish green from blue; in Kiche, *rax*, in Maya *yaax*, stands for both these shades. The names of these five main colors are constantly recuring as signs and metaphors. They are:

	Kiche.	Cakchiquel.	Maya.
White,	zak,	zak,	zac.
Black,	gek,	g'ek,	ek.
Red,	cak,	cak,	chac.
Green,	rax,	rax,	yaax.
Yellow,	gan,	g'an,	kan.

*"El lugar de Tlaloc, que era la tierra de *Phajaà*, descanso y bien aventuranza." Joseph Joaquin Granados y Galvez, *Tardes Americanas*, p. 87. (Mexico, 1778.) This author, though well acquainted with Otomi, was not proficient in Aztec. There is no *ph* nor *f* sound in Aztec. The word *pahatl* is given by Molina with the significations stated in the text.

† *Native Races of the Pacific States*, Vol. III, chap. xi.

The poverty of this list was eked out by certain terminations which modified the force of the root, as in Maya *poxen*, which indicated that the tint was light or shaded toward white (Pio Perez); and so Coto gives for the blue color of the sky *rax gorogoh* or *rax kanahoh* (s. v. *Azul*), and for brown *rax magamoh*, etc. Hence I judge that the deficiency of the color sense above referred to was apparent rather than real.

The *Popol Vuh* informs us that there is a spot where four roads meet, each of a different color, the one red, the second black, the third white, and the last yellow or green (pp. 82, 148). This is a reminiscence of the use of the colors as symbols of the cardinal points of the horizon. The same four colors were, according to Landa, used by the Mayas on their "Katun wheel," by which they counted their calendar, and each was sacred to one of the four dominical letters of their calendar.

The custom of identifying a color with one of the cardinal points was common in Yucatan and Mexico, as well as elsewhere in the New and Old World. It has been studied in both by M. de Charencey, who believes that in Mexico and Central America the original systems were as follows:*

Quaternary System.		Quinary System.	
East,	Yellow.	South,	Blue.
North,	Black.	East,	Red.
West,	White.	North,	Yellow.
South,	Red.	West,	White.
		Center.	Black.

This symbolism in the form of its existence in Guatemala has not yet been made out. I observe that in Cakchiquel the term for red, *cak*, also meant North (*cak ig*, north wind, Coto, s. v. *Ayre*).

The word *rax*, green or blue, as I have above mentioned, was used also in the sense of strong, violent, great, magnificent. It, in fact, almost lost its meaning as connoting a particular hue, and was applied, for instance, to any precious stone of no matter what color. Thus, says Coto, "á todas las piedras de estima y relucientes llama el indio *raxawon*, de qualquier "color que sean; piedra de anillo, *raxawon ru vach nar̨a*, que es el "anillo."

Both green and yellow were esteemed fortunate colors by the Cakchiquels, the former as that of the flourishing plant, the latter as that of the ripe and golden ears of maize. Hence, says Coto, they were also used to mean prosperity: "para significar prosperidad usan deste nombre *ganal*, "y *raxal* que es verde; v. g. *goh ganal, raxal, ru chahim Pedro*." The god *Kanil*, is still honored by the Kiches, as the protector of the harvest†.

Nevertheless, yellow was the color used in mourning, and the bereaved one painted himself with a yellow earth, as we learn from Ximenez: "El luto que usaban era untarse de tierra amarilla, de adonde tome el

* *Des Couleurs considérées comme Symboles des Points de l'Horizon chez les Peuples du Nouveau Monde*. Actes de la Société Philologiques, Tom. vi.

† Scherzer, *ubi supra*, p. 12.

"nombre *mal-cane* el viudo, que quiere decir el untado de amarillo" (*Escolios*, p. 214).

The color white, *sak*, had, however, by far the widest metaphorical uses. As the hue of light, it was associated, with day, dawn, brightness, etc.; to dawn, *ti saker;* the daybreak, *maha ti saker;* a clear sky, *raa cah;* light, *sak;* clearness, translucency, *sak il.* As applied to abstract ideas its employment was very frequent as "clearly, manifestly," *chi sakil.* In the Popol Vuh are such expressions as *sakil golem, sakil tzih*, literally "the whiteness life, the whiteness words," which mean "the glory of life, the glory of speech." The mythical mother and father of the race are called *sakil al, sakil qahol*, she who gives birth to whiteness, he who begets whiteness, where the whiteness is to be understood as mental clearness, knowledge, enlightenment. Varea gives *sak iricah*, to make clear, to explain, *sak*, a clearing in the woods, and other derivatives.

In closing this exegetical study, I would point out one fact developed by it, to which I attach considerable weight, and that is that the names analyzed indicate unmistakably a source immeasurably remote from Christian thought, and thus prove the aboriginal origin of this important myth. Can any one maintain that it was an echo of missionary teaching, when the names it applies to the highest god are such as "the Great Hog," "the Fox, mighty in Magic," "the Syphilitic One," and the like? Such appellations, at first sight so degrading to the notion of God, can only be understood by taking into account modes of thought, and associations of ideas wholly divergent from those to which these tribes were introduced by the ministers of the Christian religion.

Stated Meeting, December 2d, 1881.

Present, 6 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from John Evans, dated Nov. 5, 1881, Nash Mills, Hamel-Hempstead; Henry H. Gorringe, Nov. 30, Portland, Oregon; William Gladstone, Prime Minister of England, Nov. 15, 10 Downing St., Whitehall (through G. L. Gower); and B. Stallo, Nov. 18, Cincinnati.

A letter of acknowledgment was received from the Royal Institution, London. (Proc. 107, 108; Trans. XV, 3.)

A letter of envoy was received from the North China

Branch of the Royal Asiatic Society, dated Shanghai, Oct. 25, 1881.

A letter requesting the completion of sets of Proceedings and Transactions of this Society, was received from Cornell University, Ithaca, N. Y., dated Nov. 22, 1881. The matter was referred to the Secretaries, with power to act.

A circular letter was received from the Secretary of the Prince Edward Island Historical Society, dated Nov. 17, 1881, Charlottetown.

Donations for the Library were received from the Mining Bureau, Melbourne; Royal Academy, Berlin; Zoologischer Anzeiger, Leipzig; Society of Northern Antiquaries, Copenhagen; Oesterreichischer Ingenieur- und Architekten Verein, Wien; Annales des Mines, and Revue Politique, Paris; Bordeaux Society of Commercial Geography; Royal Astronomical Society, and Nature, London; Mr. Robert C. Winthrop, Boston; Essex Institute, Salem; American Journal of Sciences, New Haven; New York Historical Society; American Chemical Society, N. Y.; Academy of Natural Sciences, The American, and Mr. Henry Phillips, Jr., Philadelphia; U. S. National Museum, and the Bureau of Education, Washington; The Virginias, Staunton, Va.; and State Historical Society of Wisconsin.

A photograph and a phototype of the late member Wm. Rawle, Esq., were presented to the Society by Mr. Brooke Rawle.

A paper by Prof. J. J. Stevenson, entitled "Notes on the Laramie Group in the vicinity of Raton, New Mexico," was read by title.*

Mr. Lewis read a paper upon a new substance resembling Dopplerite found in a peat bog near Scranton.*

A communication was read from Mr. Lesley stating that he had gone away for two or three months, and enclosing a report upon the manner in which he intended to, and had already examined and partly copied the old minutes of the Society. Postponed to Dec. 16th.

* These papers will be printed in Vol. xx, No. 111.

The Treasurer's report was read and referred to the Finance Committee.

Pending nominations Nos. 935 and 946 to 950 inclusive were read.

Proceedings of the Officers and Council submitted at the last meeting, were made special order for next meeting; and to be placed on the notice cards.

On motion of Mr. Price, it was moved that $20,000 additional insurance be placed on the Library. Carried.

And the meeting was adjourned.

Stated Meeting, December 16, 1881.

Present, 16 members.

President, Mr. FRALEY, in the chair.

A letter accepting membership was received from Mr. A. Renard, Conservateur du Musée Royal d'Histoire Naturelle de Belgique, Bruxelle, dated Vienna, Nov. 19, 1881.

Letters of acknowledgment were received from the Royal Society of Edinburgh, Nov. 15, 1881 (Proc. 107, 108; Trans. XV, 3); and the Society of Antiquaries, London, Dec. 1, 1881 (107, 108; XV, 3).

Letters of envoy were received from the Physical Central Observatory, St. Petersburg, Oct., 1881; Musée Guimet, Lyon, Nov. 17, 1881; Dr. G. M. Gibson, 1 Randolph Cliff, Edinburgh, Nov., 1881; Mr. Edward Coles, 205 S. 6th Street, Philadelphia, Nov. 23, 1881, and the Department of the Interior, Washington, Dec. 12, 1881.

A postal card requesting volumes of Transactions published since Volume XII, was received from the University of Toronto, dated Dec. 8, 1881. Referred to the Secretaries.

A letter from Mr. B. V. Marsh was read, dated Dec. 9, 1881, tendering his resignation as Trustee of the Building Fund. The

resignation was accepted, and on motion the thanks of the Society were tendered to Mr. Marsh for his faithful services.

Donations for the Library were received from the Royal Society of Victoria, Melbourne; the Royal Prussian Academy, Berlin; Zoologischer Anzeiger, Leipsig; Senckenberg Natural Science Society, Frankfurt a-M.; R. Accademia dei Lincei, Rome; Geographical Society, Revue Politique and M. L. Gruner, Paris; Society of Commercial Geography, Bordeaux; Journal of Forestry, Nature, Nautical Almanac Office, and Mr. C. Wm. Siemens, London; Geo. A. Gibson, M.D., Edinburgh; Nova Scotia Institute of Natural Science, Halifax; Museum of Comparative Zoology, Cambridge; Yale College, New Haven; New York Academy of Science, and the editors of "Science," "Health and Food," and The Chemists' and Druggists' Bulletin, New York; American Journal of Pharmacy, Medical News, The American, Mr. Dalton Dorr, Mr. Henry Phillips, Jr., and Mr. Edward Coles, Philadelphia; American Journal of Mathematics, Baltimore; U. S. National Museum, Light House Board and Department of the Interior, Washington, and the Virginias, Staunton, Va.

The death of Mr. W. Milnor Roberts was announced by the President.

On motion of Mr. Henry Phillips, Jr., the President was requested to appoint a proper person to prepare an obituary notice of Mr. Roberts.

Mr. Eli K. Price read a description of the Rockery on the grounds of the University at West Philadelphia.

Prof. Cope presented two papers on the geological exploration of the Big Horn Region, with especial reference to the Eocene period.

Rev. Dr. Boardman announced that he would read a communication on the history of alphabets.

The report of the Committee of Finance was postponed to the next meeting.

Under deferred business the Society proceeded to the consideration of the resolution of the Officers and Council to celebrate the birthday of Franklin.

Mr. Phillips spoke in favor of the resolution.

The resolution was agreed to, and a Committee consisting of Mr. Henry Phillips, Jr., Mr. J. S. Price, and Mr. Wm. A. Ingham was appointed to attend to the matter.

A communication from the Librarian in reference to printing the early minutes of the Society was laid before the Society by the President.

Mr. Price moved to postpone consideration of the matter for the present.

Mr. Phillips moved that the suggestion in the Librarian's report in regard to the MSS. be referred to a committee of five to report to the Society.

Mr. Henry Phillips, Jr., Dr. Horn, Mr. H. C. Lewis, Dr. Brinton, and Mr. Philip Law were appointed as Committee.

The President announced vacancies in the Trusteeship of the Building Fund.

It was moved by Mr. Price that the Society proceed to fill the vacancy in the Trustees of the Building Fund.

On motion, Mr. Richard Wood, Mr. J. Sergeant Price and Mr. Wm. V. McKean were elected.

And the meeting was adjourned.

INDEX TO VOLUME XIX.

Stated Meetings Held.

New Members Elected.

* Members who have accepted by letter. † Members who have taken their seats.

Members Deceased.

Members Resigned.

Obituary Notices Read of

Photographs of Members Received.

*[1] Obituary notice to be prepared by Mr. James B. Townsend.

*[2] This will be printed in Vol. xx, No. 111.

---

*These papers will be published in No. 111, Vol. xx.

† This paper will be published separately as No. 110, Vol. xx.

Verbal and Short Communications, Exhibits, &c.

* These papers will be published in No. 111, Vol. xx.

Regular Business.

Correspondence. *Page.*

Proc. Amer. Philos. Soc. Vol. XIX. No. 109.

EXTRACT FROM THE BY-LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them invested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them, to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his dicovery, invention or improvement, addressed to the President or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with him the communication, description, or model, except the officer to whom it shall be entrusted; nor shall such officer part with the same out of his custody, without a special order of the Society for that purpose.

6. The Society, having previously referred the several communications from candidates for the premium, then depending, to the consideration of the twelve counsellors and other officers of the Society, and having received their report thereon, shall, at one of their stated meetings in the month of December, annually, after the expiration of this current year (of the time and place, together with the particular occasion of which meeting due notice shall be previously given, by public advertisement) proceed to final adjudication of the said premium; and, after due consideration had, a vote shall first be taken on this question, viz.: Whether any of the communications then under inspection be worthy of the proposed premium? If this question be determined in the negative, the whole business shall be deferred till another year; but if in the affirmative, the Society shall proceed

to determine by ballot, given by the members at large, the discovery, invention or improvement most useful and worthy; and that discovery, invention, or improvement which shall be found to have a majority of concurring votes in its favor shall be successful; and then, and not till then, the sealed letter accompanying the crowned performance shall be opened, and the name of the author announced as the person entitled to the said premium.

7. No member of the Society who is a candidate for the premium then depending, or who hath not previously declared to the Society, that he has considered and weighed, according to the best of his judgment, the comparative merits of the several claims then under consideration, shall sit in judgment, or give his vote in awarding the said premium.

8. A full account of the crowned subject shall be published by the Society, as soon as may be after the adjudication, either in a separate publication, or in the next succeeding volume of their Transactions, or in both,

9. The unsuccessful performances shall remain under consideration, and their authors be considered as candidates for the premium for five years next succeeding the time of their presentment; except such performances as their authors may, in the meantime, think fit to withdraw. And the Society shall annually publish an abstract of the titles, object, or subject matter of the communications, so under consideration; such only excepted as the Society shall think not worthy of public notice.

10. The letters containing the names of authors whose performances shall be rejected, or which shall be found unsuccessful after a trial of five years, shall be burnt before the Society, without breaking the seals.

11. In case there should be a failure, in any year, of any communication worthy of the proposed premium, there will then be two premiums to be awarded the next year. But no accumulation of premiums shall entitle the author to more than one premium for any one discovery, invention or improvement.

12. The premium shall consist of an oval plate of solid standard gold of the value of ten guineas. On one side thereof shall be neatly engraved a short Latin motto suited to the occasion, together with the words: "The Premium of John Hyacinth de Magellan, of London, established in the year 1786;" and on the other side of the plate shall be engraved these words: "Awarded by the A. P. S. for the discovery of ——— A. D———." And the seal of the Society shall be annexed to the medal by a ribbon passing through a small hole at the lower edge thereof.

SECTION 2. The Magellanic fund of two hundred guineas shall be considered as ten hundred and fifty dollars, and shall be invested separately from other funds belonging to or under the care of the Society, and a separate and distinct account of it shall be kept by the treasurer.

The said fund shall be credited with the sum of one hundred dollars, to represent the two premiums for which the Society is now liable.

The treasurer shall credit the said fund with the interest received on the investment thereof, and, if any surplus of said interest shall remain after providing for the premiums which may then be demandable, said surplus shall be used by the Society for making publication of the terms of the said premium, and for the addition, to the said premium, of such amount as the Society may from time to time think suitable, or for the institution of other premiums.

The treasurer shall, at the first stated meeting of the Society in the month of December annually, make a report of the state of said fund and of the investment thereof.